

CALIFORNIA ENERGY COMMISSION

1516 NINTH STREET
SACRAMENTO, CA 95814-5512
www.energy.ca.gov



March 31, 2018

Alice Stebbins, Executive Director
California Public Utilities Commission
505 Van Ness Avenue
San Francisco, CA 94102

Dear Ms. Stebbins:

On behalf of the California Energy Commission, I am pleased to submit the *Natural Gas Research and Development Program: Proposed Program Plan and Funding Request for Fiscal Year 2018-19*. Each year, by March 31, the Energy Commission submits a proposed program plan and funding request. This budget plan totals \$24 million for the period of July 1, 2018, through June 30, 2019, to fund technology innovations to support the state's energy goals and bring benefit to natural gas ratepayers. The goal of the research is to fund promising research in the following areas: energy efficiency; renewable energy and advanced generation; natural gas infrastructure safety and integrity; energy-related environmental research; and natural gas-related transportation.

The budget plan was developed based on state energy policies, legislative mandates, and a public outreach process. These include California Public Utilities Commission Decision 04-08-010, the *Integrated Energy Policy Report*, the *Energy Action Plan*, the *California Energy Efficiency Strategic Plan*, Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006), and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016).

The Energy Commission's Research and Development program staff held a public workshop on January 25, 2018, to facilitate stakeholder participation and feedback for this year's budget plan report, and present the proposed natural gas research initiatives. Recommendations from the workshop were considered and used to refine the initiatives in the proposed budget plan.

Appendix A of the report contains a link to the natural gas research initiative presentations from the January workshop. Appendix B contains a link to stakeholder questions and comments from the January workshop, and includes Energy Commission responses. The workshop audio is available on the same page.

Table 1 below shows the proposed funding for each research area. Approximately 10 percent of the total budget is allocated for administrative expenses.

Table 1: Proposed Natural Gas Budget Plan Summary FY 2018-19

Research Program Areas	FY 2018-19 Budget
Energy Efficiency	\$6.0 million
Renewable Energy and Advanced Generation	\$3.0 million
Energy Infrastructure	
<i>Natural Gas Infrastructure Safety and Integrity</i>	\$5.6 million
<i>Energy-Related Environmental Research</i>	\$3.0 million
Natural Gas-Related Transportation	\$4.0 million
Program Administration	\$2.4 million
TOTAL	\$24 million

If you have questions, please contact Laurie ten Hope, Deputy Director of the Energy Research and Development Division at laurie.tenhope@energy.ca.gov or 916-327-1521.

Sincerely,



Drew Bohan
Executive Director

cc: Laurie ten Hope, Deputy Director

Enclosure: *Natural Gas Research and Development Program: Proposed Program Plan and Funding Request for Fiscal Year 2018-19*

California Energy Commission

STAFF REPORT

Natural Gas Research and Development Program

Proposed Program Plan and Funding Request for
Fiscal Year 2018-19

California Energy Commission

Edmund G. Brown Jr., Governor

March 2018 | CEC-500-2018-006



California Energy Commission

Pilar Magaña
Primary Author

Tiffany Solorio, Lead
Nicole Dani
Project Managers

Aleecia Gutierrez
Office Manager
ENERGY GENERATION RESEARCH OFFICE

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Drew Bohan
Executive Director

DISCLAIMER

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Rizaldo Aldas

Peter Chen

Colin Corby

David Erne

Guido Franco

Anish Gautam

Reynaldo Gonzalez

Lorraine Gonzalez

Angela Gould

Yu Hou

Virginia Lew

Bradley Meister

Fernando Piña

Qing Tian

Susan Wilhelm

Kevin Uy

The authors also thank the Natural Gas Research Program's stakeholders for providing insightful input and comments on the research initiatives.

ABSTRACT

Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000) authorizes the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California. These monies fund energy efficiency programs and public interest research and development projects benefitting natural gas ratepayers. In 2004, the CPUC issued Decision 04-08-010, designating the California Energy Commission as the administrator for the research funds. The Energy Commission manages the Natural Gas Research and Development program, using competitive solicitations aligned with California's climate, energy and safety policies to support energy-related research, development, and demonstration not adequately provided by competitive and regulated markets. To help ensure a high return on ratepayer investments, administrative costs are limited to 10 percent, funds are rewarded through a competitive process, technical advisory committees inform technology development and deployment for each project, and these results are made public. The Energy Commission submits an annual proposed program plan and funding request to the CPUC for review and approval.

This *Natural Gas Research and Development Program Proposed Program Plan and Funding Request for Fiscal Year 2018-19*, describes the Energy Commission's proposed natural gas research initiatives in energy efficiency, renewable energy, and energy infrastructure, including natural gas safety and integrity. The proposed research funding for fiscal year 2018-19 is \$24 million, and the budget plan covers July 1, 2018 through June 30, 2019. The report proposes research to improve measuring emissions measurements and advance developing and deploying natural gas in heavy-duty trucks to help improve air quality in the state's severely polluted air basins. The recommendations are based on input from California stakeholders, research institutions, equipment manufacturers, and governmental partners, with several initiatives in this budget plan to benefit disadvantaged communities. These initiatives were carefully chosen while considering ongoing public outreach seeking research initiatives from California researchers.

Keywords: California Energy Commission, California Public Utilities Commission, California Air Resources Board, natural gas research, PIER, energy research, R&D, energy efficiency, renewable energy, smart energy infrastructure, public safety, disadvantaged communities, transportation

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EXECUTIVE SUMMARY

Natural gas plays an important role in California's energy system: it is used in homes and businesses mainly for space and water heating, drying and cooking, and it is used in the industrial and transportation sectors for process heating, combined cooling, heating and power, and vehicle operation. In 2016, Californians consumed about 2.1 trillion cubic feet of natural gas, with the power generation and industrial sectors accounting for more than half of consumption at 32 percent and 37 percent respectively. According to the *2017 Natural Gas Outlook*, these numbers are expected to grow slightly, with estimates showing an average demand increase of about 0.55 percent per year from 2018 to 2028.

Nearly 90 percent of California's natural gas supply comes from outside California from Canada, Mexico and the Rocky Mountain regions. This reliance on imported gas leaves the state vulnerable to price shocks, supply disruptions, and issues associated with pipeline safety and storage integrity. With California consuming roughly 5.8 billion cubic feet per day on average, and 11.157 billion cubic feet at peak times, ensuring the safety, reliability, and efficient operation of natural gas infrastructure and systems is critical in maintaining California's economic vitality and in reaching its greenhouse gas emission reduction goals.

As California continues to pursue its ambitious emission reduction and renewable energy targets to tackle climate change issues and improve public health and safety, the role of natural gas in the energy system is expected to change. For California to achieve its climate and energy goals, it is imperative to continue impartial public research and development investments in natural gas innovations and technologies. Recognizing that some applications of natural gas will switch to other fuels going forward, research is still needed to drive innovation in targeted industries and technology applications that move away from diesel or continue to rely on natural gas.

The California Energy Commission's Energy Research and Development Division administers the Natural Gas Research and Development Program (Natural Gas R&D) with oversight by the California Public Utilities Commission (CPUC) and to date, has funded 237 research agreements totaling more than \$216.6 million.

The Energy Commission Research and Development Division staff develops natural gas research initiatives guided by state energy policies, legislative mandates, and stakeholder input. Some of these key policies and mandates include CPUC Decision 04-08-010, the *Integrated Energy Policy Reports; Energy Action Plan; the California Energy Efficiency Strategic Plan*; Assembly Bill 32, the Global Warming Solutions Act (Núñez, Chapter 488, Statutes of 2006); and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016).

Research Vision and Goals

The *Natural Gas Research and Development Program Proposed Program Plan and Funding Request for Fiscal Year 2018-19* (FY 2018-19 Natural Gas R&D Budget Plan) identifies and addresses emerging natural gas-related trends that are important to California's energy future. These trends include opportunities to reduce statewide natural gas consumption through

energy efficiency and to increase and optimize the use of natural gas in various sectors such as the transportation sector, where state-of-the-art natural gas engines being introduced into the market are showing near-zero emissions for oxides of nitrogen (NO_x). Identifying market trends helps the program focus attention on the market barriers and information gaps that can be effectively addressed by future research.

Furthermore, the program coordinates with the CPUC to respond to critical research issues, such as developing technologies that increase natural gas pipeline integrity and safety and improving resilience of the natural gas system.

The Natural Gas R&D Program uses a competitive solicitation process that supports research to:

- **Assure** safe, reliable natural gas services by conducting research that focuses on the integrity and safety of the natural gas infrastructure.
- **Stimulate** California's economic growth by attracting and developing businesses and creating and supporting jobs.
- **Achieve** long-term benefits to natural gas ratepayers by developing technologies and products that provide clean, diverse, and environmentally sound energy systems.

Research Approach and Stakeholder Participation

On January 25, 2018, California Energy Commission staff held a public workshop to present the proposed natural gas research initiatives and received comments from stakeholders supporting the proposed initiatives. Recommendations from the workshop were considered and used to refine the FY 2018-19 Natural Gas R&D Budget Plan. The staff presentation given and a summary of questions and answers from the workshop are referenced in Appendices A and B of this budget plan report. The Energy Commission staff benefits from and appreciates the thoughtful comments of engaged stakeholders.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) prioritizes maximizing benefits to low-income customers and those in disadvantaged communities. Several initiatives in this budget plan are either targeted directly to or have components that benefit disadvantaged communities and include:

- Reducing natural gas use for greenhouse gas (GHG) emission-intensive industries: This initiative can include process heating efficiency improvements that reduce operating costs and air emissions from the burning of natural gas in facilities in disadvantaged communities. Since a large percentage of industrial plants are in disadvantaged communities, reductions in air emissions will improve the air quality in these communities. By reducing operating costs, building and industry owners can have more discretionary funding available to invest in their properties and businesses and be more competitive in the global marketplace.
- Converting Central Valley agricultural waste resources to energy: This initiative has the potential to reduce criteria air pollutant emissions from small dairy and farm operations in the San Joaquin Valley. The San Joaquin Valley is a nonattainment region for ozone

and particulate matter that includes several disadvantaged communities, and the local air district projects increases in open pile burning of agricultural waste. Nonattainment areas are areas considered to have air quality worse than the California Ambient Air Quality Standards. Ozone and particulate matter are linked to asthma and other respiratory illnesses, and disproportionately affect the young, sick, and elderly. Targeting emission reductions in the Central Valley's largest sector will contribute to improving air quality.

- Developing high-efficiency, low-emission, production-ready natural gas engines for long haul applications: Heavy-duty long-haul vehicle applications are a significant source of emissions. Communities around freight corridors are often disadvantaged communities partly because of the higher exposure to criteria emissions. Research supported under this initiative aims to reduce criteria emissions by improving efficiency in long-haul applications operating through heavy-traffic freight corridors.

Natural Gas Research Budget Plan for Fiscal Year 2018-19

The FY 2018-19 Natural Gas R&D Budget Plan divides the project funding among primary research initiatives into four main program areas (Table 1). The program also allocates about 10 percent of the total natural gas research budget for program administrative expenses.

Table 1: Natural Gas R&D Budget Plan Summary FY 2018-19

Research Areas	Proposed Budget
Energy Efficiency	\$6,000,000
Renewable Energy and Advanced Generation	\$3,000,000
Energy Infrastructure	
• <i>Natural Gas Infrastructure Safety and Integrity</i>	\$5,600,000
• <i>Energy-Related Environmental Research</i>	\$3,000,000
Natural Gas-Related Transportation	\$4,000,000
Program Administration	\$2,400,000
TOTAL	\$24,000,000

Source: California Energy Commission

CHAPTER 1:

Introduction and Program Overview

Recognizing the benefit of natural gas research to Californians, Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000) directed the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California to fund research and development specific to natural gas. The 2004 CPUC Decision 04-08-010 designated the California Energy Commission as the administrator for the Natural Gas Research & Development (Natural Gas R&D) program. The CPUC allocates \$24 million per year and defines public interest natural gas research activities as those “directed towards developing science or technology, and 1) the benefits of which accrue to California citizens, and 2) are not adequately addressed by competitive or regulated entities.”¹ The decision also directs Natural Gas R&D projects to:

- Focus on energy efficiency, renewable technologies, conservation, and environmental issues.
- Support state energy policy.
- Provide communitywide benefits including, but not limited to, job creation, improved air quality and economic stimulation.
- Consider opportunities for collaboration and cofunding with other entities, such as federal and local agencies.

Research Guides State Energy Policies

California energy legislation and policies guide and respond to California’s complex and evolving energy system. The Energy Commission’s natural gas R&D Program responds to and informs these policies through research, addressing directives detailed in CPUC resolutions.

Directed primarily by Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006), the Energy Commission’s natural gas research is also driven by energy policies identified in the *Integrated Energy Policy Reports (IEPR)*, *2017 Climate Change Scoping Plan*,² *Sustainable Freight Initiative*,³ and *California’s Energy Efficiency Strategic Plan*.⁴ To achieve the policy goals of Assembly Bill 32 (Núñez, Chapter 488, Statutes of 2006) and Senate Bill 32 (Pavley, Chapter 249, Statutes of

1 CPUC Decision 04-08-010, p. 24.

2 *California’s 2017 Climate Change Scoping Plan*. November 2017.
https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf?_ga=2.214355988.2032521246.1515442068-1515312640.1439561798.

3 *California Sustainable Freight Action Plan*. July 2016.
http://casustainablefreight.org/documents/PlanElements/Main%20Document_FINAL_07272016.pdf.

4 *California’s Long-Term Energy Efficiency Strategic Plan*, (September 2008),
<http://www.californiaenergyefficiency.com/docs/EEStrategicPlan.pdf>.

2016), the Energy Commission and the California Air Resources Board (CARB) work together to identify and develop technologies and strategies that can help reduce greenhouse gas emissions.

Multiple policies drive the Energy Commission's research into natural gas infrastructure safety and integrity. Based on past accidents in San Bruno and Aliso Canyon, Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014) and Senate Bill 887 (Pavley, Chapter 673, Statutes of 2016) addresses the safety and integrity of natural gas pipelines and storage facilities, respectively. Research also supports multiple CPUC policies, including the CPUC's General Order No. 112-F, which addresses the rules for utilities to design, construct, test, operate and maintain piping systems, beyond those required by federal regulations; CPUC Resolution G-3519, which directs the Energy Commission to support research studies stemming from the Aliso Canyon leak; and CPUC's Gas Safety Plan, which will improve the CPUC's safety and enforcement programs.

Recently adopted policies provide additional guidance on the future role natural gas will play in an increasingly renewable and low-emission energy system. The short-lived climate pollutant strategy (Senate Bill 1383, Lara, Chapter 395, Statutes of 2016) includes ambitious goals to reduce methane emissions, among other short-lived climate pollutants, by 40 percent below 2013 emissions by 2030. In this budget plan, several initiatives focus on increased efforts to reduce methane emissions in industries such as the dairy industry, where renewable natural gas (RNG) can be sourced through methane recovery.

In accordance with Senate Bill 350 (De León, Chapter 547, Statutes of 2015), which aims to increase clean energy funding directed to low-income and disadvantaged communities, this budget plan includes research initiatives that will support projects that benefit these communities.

Reducing emissions associated with natural gas use will be an ongoing priority as natural gas is considered a primary energy source for several industries, primarily electricity generation. The *2017 Climate Change Scoping Plan Update* continues to emphasize that the need for innovative technologies that improve efficiency, increase the production of renewable natural gas, and reduce leakage from natural gas infrastructure will be pivotal in meeting future climate change targets.⁵

Additional policies specific to the natural gas research areas are described below in Table 2.

⁵ https://www.arb.ca.gov/cc/scopingplan/2030sp_pp_final.pdf.

Table 2: Summary of Policy Drivers for Natural Gas Research and Development Activities

Research Area	Policy Drivers
<ul style="list-style-type: none"> Energy Commission's Primary Natural Gas Policy Drivers 	<ul style="list-style-type: none"> <i>Energy Action Plan</i>⁶ <i>Integrated Energy Policy Report (IEPR)</i>⁷ Assembly Bill 32 (Núñez, Chapter 488 Statutes of 2006)⁸ — California Global Warming Solutions Act of 2006 Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006)⁹ Senate Bill 32 requires California to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030. Public Utilities Code Section 895 provides statutory authority for the Energy Commission to administer the natural gas funds using the PIER statutes.¹⁰
<ul style="list-style-type: none"> An Energy-Efficient California: Initiatives focused on buildings energy end use: efficiency; industrial, agriculture, and water efficiency; and energy efficiency-related environmental research. 	<ul style="list-style-type: none"> Energy Efficiency Buildings Standards (Title 24, Part 6) — goals for 2019 Standards¹¹ <ul style="list-style-type: none"> Increase building energy efficiency cost effectively. Make progress toward ZNE within the confines of net energy metering and life cycle costing rules. Contribute to the State's GHG reduction goals. Ensure real benefits for building occupants with positive benefit to cost ratios. Appliance Energy Efficiency Standards (Title 20, Division 2, Chapter 4, Article 4, Sections 1601-1608: <i>Appliance Efficiency Regulations</i>) Assembly Bill 758 (Skinner, Chapter 470, Statutes of 2009) achieves greater energy savings in existing residential and nonresidential buildings. Assembly Bill 531 (Saldaña, Chapter 323, Statutes of 2009) discloses commercial building electric and natural gas use. Senate Bill 350 (De León, Chapter 547, Statutes of 2015) establishes annual targets for statewide energy efficiency savings and demand reduction that will achieve a cumulative doubling of statewide energy efficiency savings for retail customers by January 1, 2030.

6 http://www.energy.ca.gov/energy_action_plan.

7 http://www.energy.ca.gov/2017_energypolicy.

8 http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_0001-0050/ab_32_bill_20060927_chaptered.html.

9 http://www.leginfo.ca.gov/pub/05-06/bill/sen/sb_1201-1250/sb_1250_bill_20060927_chaptered.pdf.

10 <http://www.leginfo.ca.gov/cgi-bin/displaycode?section=puc&group=00001-01000&file=890-900>.

11 Cox, Rory. October 24, 2017. *It All Adds up to Zero, California's Zero- Net -Energy Future*, California Public Utilities Commission, Bay REN Forum.

Research Area	Policy Drivers
	<ul style="list-style-type: none"> • <i>California Energy Efficiency Strategic Plan</i>¹² establishes the following goals: <ul style="list-style-type: none"> ◦ Zero-net-energy (ZNE) buildings: all new residential construction by 2020 and 100 percent new commercial buildings by 2030. ◦ Transformation of the heating, ventilation, and air-conditioning (HVAC) industry to ensure that the performance of HVAC equipment is optimized for California's climate zones. ◦ Significant increases in the efficiency of natural gas use and on-site renewable energy use in the agriculture sector.
<ul style="list-style-type: none"> • A Renewable Future: Renewable research initiatives target combined heat and power (CHP) and renewable energy-related environmental research and are driven by renewable energy generation and greenhouse gas reduction goals. 	<ul style="list-style-type: none"> • Senate Bill X1-2 — Renewables Portfolio Standard¹³ (Simitian, Chapter 1, Statutes of 2011) The Renewables Portfolio Standard sets goals for 20 percent of retail sales from renewable energy resources by end of 2013, 25 percent by end of 2016, and 33 percent by end of 2020. • Assembly Bill 1613, the Waste Heat and Carbon Emissions Reduction Act (Blakeslee, Chapter 713, Statutes of 2007)¹⁴ — The Waste Heat and Carbon Emissions Reduction Act requires an electrical corporation to purchase excess electricity from combined-heat-and-power systems that comply with sizing, energy efficiency, and air pollution control requirements. • Senate Bill 350, Clean Energy and Pollution Reduction Act of 2015 (De León, Chapter 547, Statutes of 2015)¹⁵ Increases the electricity generated and sold to retail customers per year from eligible renewable energy resources to 50% by December 31, 2030. • Governor Brown's <i>Clean Energy Jobs Plan</i>¹⁶ – Provides that California should develop 12,000 megawatts (MW) of localized energy by 2020, establishes a timeline to make new homes and commercial buildings in California “zero net energy,” and provides incentives for the increased use of cogeneration by 6,500 MW by 2030. • <i>Bioenergy Action Plan</i>¹⁷ to implement Executive Order S-06-06, which set goals for the production and use of electricity and fuels made from biomass.

12 http://www.energy.ca.gov/ab758/documents/CAEnergyEfficiencyStrategicPlan_Jan2011.pdf.

13 <http://www.energy.ca.gov/portfolio>.

14 http://www.leginfo.ca.gov/pub/11-12/bill/asm/ab_1601-1650/ab_1613_bill_20120208_introduced.pdf.

15 http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_0301-0350/sb_350_bill_20151007_chaptered.pdf.

16 http://gov.ca.gov/docs/Clean_Energy_Plan.pdf.

17 http://www.energy.ca.gov/bioenergy_action_plan.

Research Area	Policy Drivers
	<ul style="list-style-type: none"> CARB's Short-Lived Climate Pollutant Reduction Strategy – recommends actions to reduce emissions of short-lived climate pollutants (SLCPs), which include black carbon (soot), methane (CH₄), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs), including those from dairies, organics disposal, and wastewater.
<ul style="list-style-type: none"> A Reliable, Secure, and Smart Energy Infrastructure: Initiatives target natural gas infrastructure research associated with natural gas pipeline integrity and environmental research. 	<ul style="list-style-type: none"> Public Resources Code 25620¹⁸—For the state to undertake public interest energy research, development, and demonstration projects that are not adequately provided for by competitive and regulated energy markets and to advance energy science or technologies of value to California ratepayers through investments in advanced transportation technologies that reduce air pollution and greenhouse gas emissions beyond applicable standards, and benefit electricity and natural gas ratepayers. High Energy Efficiency, Low Emissions Combustion, and Control Technology Development Program¹⁹—Addresses the goal to improve environmental quality while meeting the wide-ranging demand for energy per the 2003 <i>Integrated Energy Policy Report</i>. Assembly Bill 1496 (Thurmond, Chapter 604, Statutes of 2015), Methane Emissions. Requires the State to monitor methane hotspots.²⁰ CARB's Short-Lived Climate Pollutant Reduction Strategy – recommends actions to reduce emissions of short-lived climate pollutants (SLCPs), which include black carbon (soot), methane (CH₄), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs), including those from dairies, organics disposal, and wastewater.²¹
<ul style="list-style-type: none"> A Reliable, Secure, and Smart Energy Infrastructure: Initiatives that evaluate and resolve environmental effects of energy production, delivery, and use in California; explore how new energy applications and products can solve or reduce environmental problems. 	<ul style="list-style-type: none"> Executive Order B-29-15—Established actions to save water, increase enforcement to prevent wasteful water use, streamline the state's drought response, and invest in new technologies that will make California more drought-resilient. Executive Order B-30-15—Set greenhouse gas reduction target of 40 percent below 1990 levels by 2030. January 6, 2016, proclamation to declare an emergency and detail the administration's ongoing efforts to protect public health and safety and ensure accountability of gas storage

18 http://www.energy.ca.gov/renewables/documents/sb_1250_bill_20060927_chaptered.pdf.

19 <http://www.arb.ca.gov/planning/sip/sip.htm>.

20 https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1496.

21 <http://www.calrecycle.ca.gov/climate/slcp/>.

Research Area	Policy Drivers
	<p>facilities.</p> <ul style="list-style-type: none"> • SB 1371 (Leno, Chapter 525, Statutes of 2014. Natural Gas: leakage abatement)²²—with priority given to safety, reliability, and affordability of service, the CPUC must determine whether existing practices are effective at reducing methane leaks and promoting public safety and whether alternative practices may be more effective. • I1702002 – CPC Order Instituting Investigation under Senate Bill 380 (Pavley, Chapter 14, 2016) to determine the feasibility of minimizing or eliminating the use of the Aliso Canyon natural gas storage facility in the Los Angeles County while maintaining energy and electric reliability for the region.
<ul style="list-style-type: none"> • A Cleaner Transportation System: Initiatives support vehicle and component technology advancements and improvements in advanced renewable gas production systems 	<ul style="list-style-type: none"> • Executive Order B-32-15²³ – Directed the development of the Sustainable Freight Action Plan,²⁴ which establishes the following targets: improve freight system efficiency by 25 percent by 2030, deploy more than 100,000 freight vehicles and equipment capable of zero-emission operation and maximize near-zero freight vehicles and equipment powered by renewables by 2030, ensure the strategies for achieving these targets, and consider impacts on future economic growth and competitiveness. • <i>California's 2017 Climate Change Scoping Plan</i>²⁵ – The transportation sector directly accounts for 39 percent of the state's GHG emissions. A 27-32 percent reduction in GHG emissions from the transportation sector is required to meet the state's 2030 GHG reduction goals. • <i>2016 Mobile Source Strategy</i>²⁶ – Reduce emissions from the heavy-duty truck sector with cleaner combustion engines, renewable fuels, and zero-emission technology to meet GHG reduction targets and attain federal health-based air quality standards for ozone and particulate matter. Off-road equipment must reflect this same type of transformation to a mix of zero-emission and near-zero-emission technologies operating on renewable fuels. • Low Carbon Fuels Standard (LCFS)²⁷ – Reduce the full fuel-cycle carbon intensity of transportation fuels pool used in California by encouraging the transition to cleaner/less-polluting fuels that have a lower carbon footprint.

22 http://www.leginfo.ca.gov/pub/13-14/bill/sen/sb_1351-1400/sb_1371_bill_20140921_chaptered.pdf.

23 <https://www.gov.ca.gov/news.php?id=19046>.

24 http://www.casustainablefreight.org/documents/PlanElements/Main%20Document_FINAL_07272016.pdf.

25 https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

26 <https://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc.pdf>

27 <https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf>.

Importance of Natural Gas Research

More than 90 percent of California's natural gas supply comes from outside the state through an integrated North American natural gas market. These primary supplies are imported from regions including the Southwest, Canada and the Rocky Mountains.²⁸ By 2025, Energy Commission staff estimates that in-state production will account for only about 2 percent.²⁹ California has 375.5 billion cubic feet of maximum storage capacity, owned by both gas utilities and independent storage operators. Gas storage provides seasonal and daily balancing of supply and demand. This balancing allows utilities to meet higher peak demand than pipeline infrastructure is able to meet alone. Typically storage levels fluctuate throughout the year based on demand, with gas being withdrawn in the winter to meet the higher demand for heating needs, and more gas being injected during the spring and summer when demand and gas prices are typically lower. With the reliance on imported gas and with an expected growth in demand, California is susceptible to price shocks, supply disruptions, and issues associated with pipeline safety and storage integrity, particularly in peak months when demand is higher.

Demand for natural gas is expected to grow slowly at roughly 0.55 percent per year through 2028, according to the California Energy Commission's *California Energy Demand 2018-2028 Preliminary Forecast*. This forecast is based on a mid-demand case scenario and represents a "business-as-usual" environment and with consideration to current policy mandates such as the Renewables Portfolio Standard, SB 350, and efficiency mandates.³⁰ In 2016 California consumed about 2.1 trillion cubic feet (tcf), or about 5.8 billion cubic feet (bcf) per day, in homes, businesses, vehicles, factories, and power plants for electric generation.

Electricity generation and the industrial sector account for most of the natural gas use in California. About 32 percent of the natural gas is used in electricity generation, which translates to 50 percent of the gigawatt-hours (GWh) produced in California in 2016. The state's natural gas power plants have actually been able to generate 27 percent more energy using 2 percent less natural gas than 15 years ago because of effective thermal efficiency improvements.³¹ Demand from the industrial sector has also grown since 2010 by 1,173 bcf, or 15 percent. Some of this growth can be attributed to the growth in combined-heat-and-power installations, particularly in the 1990s, and to lower natural gas prices.³²

Figure 1 provides a breakdown of natural gas use per sector in 2016.

28 Brathwaite, Leon D, Jason Orta, Peter Puglia, Anthony Dixon, and Robert Gulliksen. 2017. *2017 Draft Natural Gas Market Trends and Outlook*. California Energy Commission. Publication Number: CEC-200-2017-009-SD.

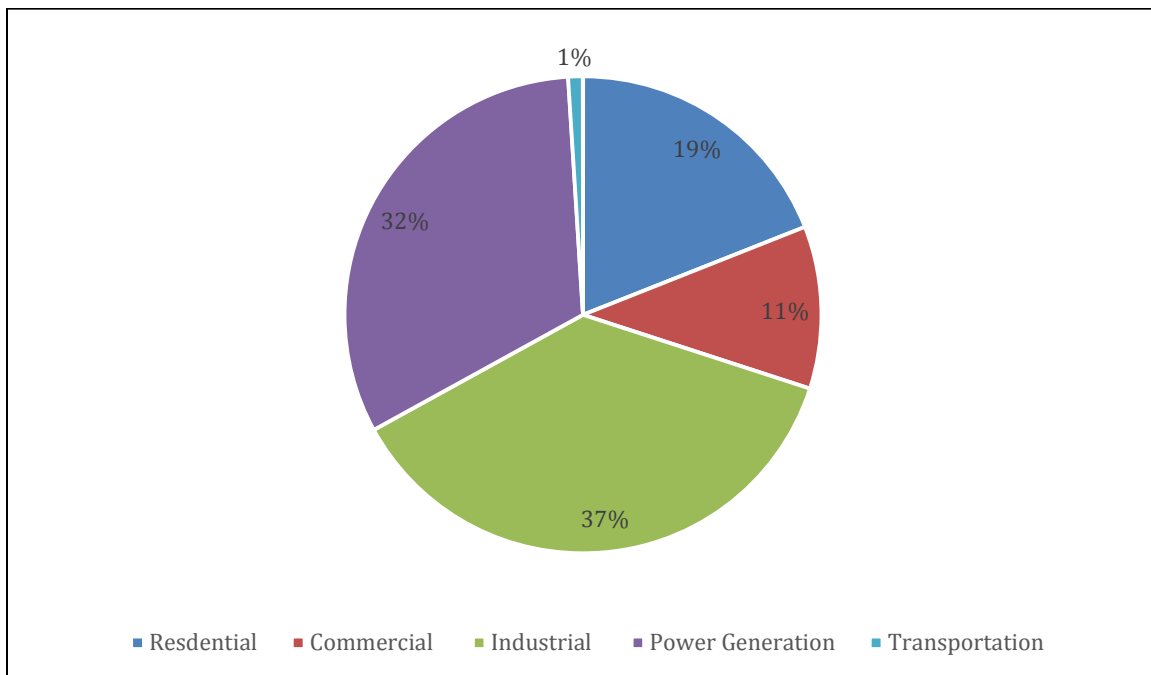
29 Ibid.

30 Brathwaite, Leon D, Jason Orta, Peter Puglia, Anthony Dixon, and Robert Gulliksen. 2017. *2017 Draft Natural Gas Market Trends and Outlook*. California Energy Commission. Publication Number: CEC-200-2017-009-SD, Page 1.

31 California Energy Commission staff. 2017. *2017 Integrated Energy Policy Report*. California Energy Commission. Publication Number: CEC-100-2017-001-CMF.

32 Brathwaite, Leon D, Jason Orta, Peter Puglia, Anthony Dixon, and Robert Gulliksen. 2017. *2017 Draft Natural Gas Market Trends and Outlook*. California Energy Commission. Publication Number: CEC-200-2017-009-SD, Page 11.

Figure 1: Percentage Use of Natural Gas by Sector in California (2016)



Source: U.S. Energy Information Administration

While average natural gas demand is expected to grow, forecasts show variability in demand projections by sector. Forecasts indicate that gas-fired generation will decrease at an annualized rate of about 1.5 percent between 2017 and 2028 however, the residential commercial and industrial sectors show average growth rates that vary between 0.37 percent and 0.90 percent for the same time frame.³³ While the role of natural gas in electric generation may change, it will continue to play an important role in the ability of natural gas facilities to provide ramping capacity for the load changes when renewable generation is not available and can serve as a replacement during extreme events like wildfires when transmissions lines may be de-energized.³⁴ As natural gas consumption decreases or remains level in most industries over the next decade, it is expected to increase in the transportation sector. While transportation accounts for only about 1.8 percent of natural gas consumption in California, this number is expected to increase significantly due to the growing number of natural gas trucks in the heavy-duty vehicles sector. Consumption of natural gas in California's transportation sector has grown from fewer than 1 million gasoline gallon equivalent (GGE) in 1991 to almost 180 million GGE in 2014.³⁵ Used primarily to fuel large vehicles such as urban

33 Brathwaite, Leon D, Jason Orta, Peter Puglia, Anthony Dixon, and Robert Gulliksen. 2017. *2017 Natural Gas Market Trends and Outlook*. California Energy Commission. Publication Number: CEC-200-2017-009-SF.

34 California Energy Commission staff. 2017. *2017 Integrated Energy Policy Report*. California Energy Commission. Publication Number: CEC-100-2017-001-CMF. Page 246.

35 Bahreinian, Aniss, Eva Borges, Jesse Gage, Bob McBride, Gordon Schremp, Ysbrand van der Werf and Gary Yowell. 2015. Staff Draft Report, *Transportation Energy Demand Forecast, 2016-2026*. California Energy Commission. Publication Number: CEC-200-2015-008-SD.

transit buses, refuse trucks, public fleets and utility trucks, natural gas demand will have the greatest growth potential in heavy-duty trucks with high annual mileage. Growth of natural gas demand for refuse trucks and transit buses is limited since the current share of natural gas-powered vehicles is already high.³⁶

Overall, these increases are regarded as modest considering that California's population has grown 31 percent since 1990. These results are due to successfully implementing aggressive energy efficiency standards for buildings, appliances, and utilities, reflecting the strides California has made in improving the overall performance of its complex energy system.³⁷

Natural gas is a critical source of energy; 32 percent of the natural gas burned in California was used for electricity generation with the remainder consumed in the residential (19 percent), commercial (11 percent), industrial (37 percent), and transportation (1 percent) sectors.³⁸

Natural gas has also contributed significantly to California's ability to integrate renewable energy sources into the energy system, acting as a source of back-up generation to address intermittency issues associated with renewable integration into the grid. While natural gas generation is relatively clean compared to other fossil fuels like coal, California will not meet its long-term greenhouse gas reduction goals or air quality mandates without significant improvements in natural gas efficiency and technology breakthroughs that will optimize the use of natural gas in sectors that will experience difficulties in electrifying.

Since 2004, the Natural Gas R&D program has invested in research to develop technologies, tools, and strategies that increase energy efficiency, reduce energy cost, reduce air pollutants and greenhouse gas emissions, and improve the safety of pipeline infrastructure. For instance, current research on natural gas inspection technologies used throughout the world is helping identify the most appropriate technologies for inspecting and monitoring pipelines in California. A catalog of the most promising technologies will guide utilities and pipeline operators in selecting the best and most cost-effective tools, increasing safety and reliability of natural gas pipelines for all Californians. Additional examples of research activities are found in Appendix A of this budget plan report.

The *Natural Gas Research and Development 2017 Annual Report* provides a full review of program achievements to the CPUC annually and describes the natural gas research activities in fiscal year 2017-18.³⁹

Research Vision and Goals

The Energy Commission's Natural Gas R&D program focuses on identifying and addressing research of emerging natural gas-related trends important to California's energy future. These trends include reducing statewide natural gas consumption through energy efficiency; using

³⁶ Ibid. page 71.

³⁷ State of California, Department of Finance "California Population Estimates, with Components of Change and Crude Rates, July 1, 1900-2016." December 2016, <http://www.dof.ca.gov/Forecasting/Demographics/Estimates/E-7/>.

³⁸ http://www.energy.ca.gov/almanac/naturalgas_data/overview.html.

³⁹ <http://www.energy.ca.gov/2017publications/CEC-500-2017-036/CEC-500-2017-036.pdf>.

natural gas efficiently through combined heat and power or cogeneration; exploring opportunities for nontraditional natural gas alternatives such as biogas and other renewable gas replacements; avoiding natural gas losses and increasing safety by improving pipeline integrity; and using natural gas to diversify California's transportation fuel mix and reduce petroleum consumption.

CHAPTER 2:

Natural Gas Research Budget Plan for Fiscal Year 2018-2019

Developing Research Initiatives

Stakeholder Participation and Strategic Partnerships

The Energy Commission engages with stakeholders to develop a research portfolio responding to challenges in the natural gas sector. Stakeholders provide invaluable input in developing research initiatives, and in some cases, they become partners on research projects with mutual benefits. For example, the current National Ambient Air Quality Standards (NAAQS) requirements for ozone attainment cannot be achieved in California's worst air basins without significant reductions in oxides of nitrogen (NO_x) emissions from heavy-duty vehicle fleets. The Energy Commission cofunded research with the South Coast Air Quality Management District (SCAQMD) and Southern California Gas Company (SoCalGas) to develop an engine technology that reduces NO_x emission rates to 90 percent below the 2010 standard.⁴⁰ The research projects will include a production readiness plan to help accelerate natural gas engine technologies on the path to commercialization.

The Energy Commission also collaborates with other California stakeholders, research institutions, governmental agencies, and industry and utility representatives to develop a shared vision of natural gas public interest energy research projects. This outreach improves accountability, transparency, communication, and responsiveness. The Energy Commission relies on these strategic partnerships to avoid duplication, build upon previous R&D work, generate new ideas, leverage public and private investments, and ensure the research portfolio provides benefits to the state's natural gas ratepayers.

Commitment to Diversity

California is a diverse state, both in geography and population. To better serve all Californians, the California Energy Commission strives to increase diversity in its programs through outreach, funding opportunities, and planning.

In April 2015, the Energy Commission unanimously approved a formal Diversity Policy Resolution, consistent with state and federal law, to improve fair and equal opportunities for small businesses; women-, disabled veteran-, minority-, and LGBT-owned business enterprises; and economically disadvantaged and underserved communities to participate in and benefit from, Energy Commission programs.

⁴⁰ Observed rates below 0.02 grams per brake horsepower hour.

Assembly Bill 865 (Alejo, Chapter 583, Statutes of 2015) provided additional guidance, requiring the Energy Commission to develop and implement a comprehensive outreach plan to broaden and diversify the applicant pool to Energy Commission programs and track progress toward those objectives.

Senate Bill 350 (De León, Chapter 547, Statutes of 2015) also took steps to ensure California's clean energy transformation includes a strong focus on equity to ensure all Californians, especially those in the most vulnerable communities, realize benefits.

The Energy Commission established a Diversity Task Force, under AB 865, to consider and make recommendations about diversity in the energy industry, including diversity of corporate governing boards and procurement from diverse businesses, and addressing and promoting local and targeted hiring. The Energy Commission also created a Disadvantaged Communities Advisory Group, as outlined in SB 350, to advise the Energy Commission and the CPUC on ways to help disadvantaged communities benefit from proposed clean energy and pollution reduction programs, expand access to clean energy technologies and receive affordable energy services. Furthermore, in its SB 350 Barriers Report, the Energy Commission recommended that the Energy Commission and CPUC should direct research, development, demonstration, and market facilitation programs to include targeted benefits for low-income customers and disadvantaged communities.⁴¹

Energy Commission staff has continued to conduct activities to meet these important commitments. Some of these efforts include:

- Continuing and advancing an outreach plan to ensure women, minorities, LGBT individuals, and disabled veterans are informed and educated about R&D program activities and encouraged to participate in R&D project funding opportunities.
- Assisting applicants in understanding how to apply for funding from the Energy Commission's programs.
- Continuing and advancing efforts to address energy-related challenges and opportunities in economically depressed communities.
- Continuing to track, monitor, and report on the participation of California-based entities and women-, minority-, disabled-veteran-owned, and small businesses for the recipients of R&D awards using the same definitions used by the investor owned utilities via CPUC General Order 156.⁴²

The Energy Commission has undertaken several activities in 2017 to demonstrate its commitment to ensure a diverse range of applicants have the opportunity to participate in R&D projects by implementing activities supporting these goals.

41 http://docketpublic.energy.ca.gov/PublicDocuments/16-OIR-02/TN214830_20161215T184655_SB_350_LowIncome_Barriers_Study_Part_A_Commission_Final_Report.pdf.

42 <http://docs.cpuc.ca.gov/publisheddocs/published/g000/m152/k827/152827372.pdf>.

Activities included:

- Enhancing the Energy Commission's website to reflect the agency's commitment to diversity.
- Broadening the use of social media platforms to educate and inform.
- Collaborating with the Commission's Public Adviser to promote grant-funding opportunities.
- Meeting with community leaders, stakeholders, and business leaders.
- Distributing R&D informational materials at conferences, meetings, and public events such as:
 - Small Business Workshop & Business Exchange, presented by the Sacramento Hispanic Chamber of Commerce, Sacramento Black Chamber of Commerce, and the Sacramento Rainbow Chamber of Commerce (January 18).
 - VerdeXchange 2017 Conference (January 29-30).
 - Food Processing Expo 2017, presented by the California League of Food Processors (February 7-8).
 - Transformative Climate Communities Stakeholder Summit, presented by the California Strategic Growth Council (February 10).
 - World Agricultural Expo, presented by the International Agri-Center (February 16).
 - CSUS College of Engineering and Computer Science 2017 Career Day, presented by CSU, Sacramento (February 17).
 - Informational Open House on Military, presented by the Governor's Office of Planning and Research and the Governor's Military Council and Navy Region Southwest (February 28).
 - Webinar on Emerging Technologies: Getting to Zero Net Energy Buildings: Present and Future (March 9).
 - Diversity Career Fair, presented by the California Energy Commission (March 30).
 - Customers of State Climate Science Research, presented by the California Energy Commission and the California Public Utilities Commission (April 11).
 - Emerging Technologies Summit, presented by the Emerging Technology Coordinating Council (April 19-21).
 - Exploring Dimensions of Community Engaged Scholarship, presented by the University of California, Davis (May 5).
 - State Scientist Day, presented by the California Association of Professional Scientists (May 10).
 - Merced Safeguarding California Workshop, presented by the California Natural Resources Agency (May 16).
 - Bay Area Safeguarding California Workshop, presented by the California Natural Resources Agency (May 22).
 - Los Angeles Safeguarding California Workshop, presented by the California Natural Resources Agency (May 31).

- LA Energy Cluster Meeting and Regional Energy Innovation Cluster (REIC) Launch, presented by the Los Angeles Cleantech Incubator (May 31).
- Sierra Nevada Safeguarding California Workshop, presented by the California Natural Resource Agency (June 14).
- IEPR – Joint Agency Workshop on Renewable Gas, presented by the California Energy Commission, the California Public Utilities Commission, and the California Air Resources Board (June 27).
- IEPR Joint Agency Workshop on Application of Distributed Energy Resources on the California Grid presented by the California Energy Commission, California Public Utilities Commission, and the California Independent System Operator (June 29).
- Microgrid Roadmap Scoping Workshop presented by the California Energy Commission, California Public Utilities Commission, and the California Independent System Operator (July 26).
- Joint Agency Workshop on SB 350 Low-Income Barriers Study Implementation, presented by the California Energy Commission, and the California Public Utilities Commission (August 1).
- IEPR Workshop on Barriers to Demand Response, presented by the California Energy Commission (August 8).
- Webinar on Emerging Technologies: Phase Change Materials, presented by the California Energy Commission (August 16).
- Technical Symposium on Avian-Solar Interactions, presented by the Multiagency Avian-Solar Collaborative Working Group and the Avian Solar Working Group (August 16).
- Combined Heat and Power (CHP) Technical and Market Assessment Workshop, presented by ICF (August 21).
- DGS Boiler Plant Tour, presented by the California Women in Energy (August 25).
- IEPR Workshop on Climate Adaptation and Resilience for the Energy System, presented by the California Energy Commission, and the California Public Utilities Commission (August 29).
- Fourth Assessment Quarterly Meeting, presented by the California Energy Commission, the California Natural Resources Agency, and the Department of Water Resources (September 11).
- Cal-Adapt User Needs Assessment Workshop, presented by the UC Berkeley Geospatial Innovation Facility (September 12)
- Civic Spark 2017 Orientation, presented by the Local Government Council (September 13).
- Secrets to Successful Proposals in California, presented by Pacific Gas and Electric (September 18).
- ETCC Quarterly Meeting: The Changing Energy Landscape for Industrial Customers, presented by the Emerging Technologies Coordinating Council (September 20).
- SBIR Workshop, presented by the Small Business in Research Program (September 25).
- Activate 2017, presented by Activation Energy and Cyclotron Road (September 28).

More information about these and other Energy Commission diversity commitment activities is available at <http://www.energy.ca.gov/commission/diversity/>.

Collaborative Roadmaps and Technology Assessments

Roadmaps and technology assessments are planning mechanisms and communication tools that establish a clear link between research and key California energy policy goals. Research roadmaps define the topic area, significant issues and barriers, data gaps, information needs, research priorities, and potential partnerships. Energy Commission staff and a wide range of energy researchers and consumers participate in “road mapping” in many program areas.⁴³ Participants can identify natural gas research needs by program area and where they overlap. Collaborative thinking about energy solutions that cut across policy boundaries is integral to leveraging research dollars. Bringing natural gas and electricity stakeholders together to develop roadmaps minimizes resource shifting, encourages innovation, documents the process for better transparency, and yields outcomes more likely to address challenges that involve both areas. An example of a completed roadmap is the *2015 Natural Gas Vehicle Research Roadmap*⁴⁴, which provides research recommendations on natural gas vehicle range and storage, engine performance and availability, emissions and environmental performance, and analysis and information sharing.

A technology assessment of the chemical and allied products industry was the focus of a grant funding opportunity (GFO) in 2017. The project identifies technologies and approaches to reduce natural gas use in the chemical and allied products industry. This industry is the fourth largest consumer of natural gas among California industries, using nearly 370 million therms annually.⁴⁵ The assessment is anticipated to be completed in 2019.

ICF, a global consulting services company, is developing a comprehensive assessment of small and microscale CHP technical and market potential in California, focusing on residential, commercial, and light industrial markets that have a peak electrical demand less than 5 megawatts. The assessment will consider conventional, renewable gas-fueled and hybrid CHP technologies, applications and their potential. Preliminary results have shown about 10 GW of total technical potential led by commercial office buildings, restaurants, and retail stores. When considering present-day rates and incentives, the total technical potential is about 1 GW of expected market adoption over the next 20 years, mostly in PG&E territory. The assessment is anticipated to be completed by fall 2018.

To identify emerging research trends and gaps, the Energy Commission solicits direct feedback and recommendations from utilities, other state agencies, academic experts, industry associations, and technology developers. Meetings, workshops, and working groups provide a

⁴³ Various roadmaps can be found at <http://www.energy.ca.gov/publications/searchReports.php?title=roadmap>.

⁴⁴ Chen, Peter. 2015 *Natural Gas Vehicle Research Roadmap*. CEC-500-2015-091.
<http://www.energy.ca.gov/2015publications/CEC-500-2015-091/CEC-500-2015-091-CMF.pdf>.

⁴⁵ 2015 estimates.

vehicle for California stakeholders to understand past, present, and future research and to provide guidance, recommendations, and improvements for the current program.

Public Meetings in 2017

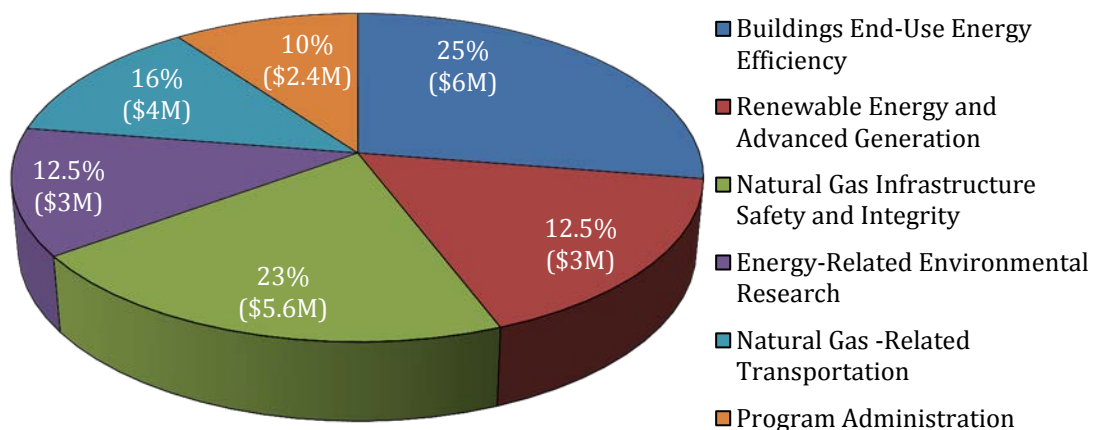
The Energy Commission's Natural Gas R&D program staff held the following public meetings in the 2017-2018 Fiscal Year:

- **December 21, 2017** - Staff Workshop to Discuss Heating, Ventilation and Air Conditioning (HVAC) Research and Development
- **August 16, 2017** - Webinar - Emerging Technologies: Phase Change Materials
- **July 7, 2017** - Staff Workshop on Natural Gas Infrastructure Safety and Integrity Research Program
- **April 11, 2017** - Lead Commissioner Workshop: Customers of Climate Science Research
- **March 9, 2017** - Webinar - Getting to Zero Net Energy Buildings: Present and Future

Proposed Budget

The Energy Commission's *Natural Gas Research and Development Program Proposed Program Plan and Funding Request for Fiscal Year 2018-19* for \$24 million is guided by the state policies identified in Table 2 in Chapter 1. The breakdown of the use of those funds is illustrated in Figure 2.

Figure 2: Proposed Natural Gas Research Initiatives Budget Percentages for FY 2018-2019



Source: California Energy Commission

Update to Potential Increase in Natural Gas R&D Funding

In the *Natural Gas Research and Development Program 2017 Annual Report*⁴⁶, staff discussed the need to better understand the changing role of natural gas in the state's energy system. Since the inception of the program in 2004, research has focused on using natural gas as cleanly and efficiently as possible, fostering the role of natural gas as a low-emission transportation fuel, cultivating technologies that produce and use biogas, improving natural gas and biogas-fueled distributed generation and combined-heat-and-power systems, understanding the effects and interactions of the natural gas system on the environment, and supporting technologies and strategies to reduce leakages and improve the safety of the natural gas system. Since this time, the California energy system has also rapidly transitioned away from dirtier fossil fuels such as oil in favor of natural gas due to the significant reduction in criteria pollutant and carbon emissions. Increased natural gas use in the energy system has already significantly contributed to achieving California's short-term greenhouse gas (GHG) reduction goals.

However, the energy landscape is constantly changing. Visionary mandates and goals to reduce GHG emissions in California, such as reducing GHG emissions by 2050 to 80 percent below 1990 levels, will require significant and long-term changes to the California energy system. Even with a lower carbon content compared to other fossil fuels, these goals suggest that natural gas consumption in California must decline and pathways toward decarbonization must be explored. There is an immediate need to research how natural gas use must change to meet California's GHG emission goals. In addition to these goals, critical incidents such as the San Bruno pipeline explosion (2010) and Aliso Canyon gas storage facility leak (2015) have added to the need to research and improve the safety and integrity of the natural gas system. Finally, environmental events such as the prolonged drought, extensive tree mortality, climate change-related subsidence and seawater rise have broadened the research topics into new areas.

The Energy Commission has explored these priority topics by shifting funds toward increased research in water-energy efficiency, biogas, methane emissions, and natural gas system safety. It has become apparent, however, that the current funding level limits the ability of the program to sufficiently address these time critical issues. Despite these expanding research needs, program funding has not increased since 2009.

To address this limitation, the Energy Commission anticipates submitting a formal request to the CPUC in summer 2018. In response to the request, staff anticipates the CPUC will conduct a proceeding to explore possible expansion of the Natural Gas Research and Development Program. This request will include the proposed funding levels for the expanded program, the program schedule, and a summary of planned research initiatives. Before submitting this request the Energy Commission will solicit input from natural gas utilities, research organizations, and other interested stakeholders through public workshops, written comments, and other feedback methods.

⁴⁶ *Natural Gas Research and Development Program 2017 Annual Report*.
<http://www.energy.ca.gov/2017publications/CEC-500-2017-036/CEC-500-2017-036.pdf>.

The proposal for the expanded research program is under development and is expected to consider modifications to broaden the program scope including re-establishing a small grant program to fund early stage technologies, market facilitation to move promising technologies to market, and cost-share programs to leverage federal, state, and local government-funded research programs. Finally, staff anticipates the proposal for the expanded program will be structured to build in-state capabilities for research in areas that lack resources to expand and advance technologies in their respective sectors – namely pipeline safety.

Staff anticipates the proposal will also ask the CPUC to allow changing the submission of research plans from every year (annual plans) to every three years (triennial plans). The Energy Commission has submitted the *Natural Gas Research and Development Program Budget Plan* annually to the CPUC for approval since 2005. However, this can result in research initiatives that have a short-term perspective on future research. In administering the Electric Program Investment Charge (EPIC) program, the Energy Commission has noted several advantages for planning research and development activities over a longer period. These advantages include the ability to aggregate, or combine, funding across fiscal years to create fewer but larger and more effective funding opportunities, an increased applicant pool due to the larger funding opportunities, positive feedback from researchers because of additional preparation time for upcoming funding opportunities, and a longer horizon which allows the potential to transition some technologies from development to pre-commercial demonstration in one three year investment plan cycle. All program details are subject to change based on feedback from CPUC, stakeholders, and further development from Energy Commission staff and leadership.

Ultimately, staff plans to propose that the expanded natural gas research program aims to fund research that will more effectively contribute to the state's statutory energy goals. The Energy Commission plans to include in its application to the CPUC an evaluation of the Natural Gas Research and Development Program.

Stakeholder Support to Increase Natural Gas R&D Funding

During the public staff workshop held on January 25, 2018, staff presented initiatives as a part of the proposed program expansion. Stakeholders generally supported the expansion and provided feedback on the proposed funding areas.

The Energy Commission appreciates the thoughtful comments of several stakeholders and plans to file a formal request to the CPUC requesting consideration of a funding increase. At that time, the Energy Commission will respond fully to the questions posed in the CPUC Resolution G-3519 to inform CPUC review of the overall funding levels of the program.

Proposed Research Initiatives

This proposed \$24 million Fiscal Year 2018-19 (FY 2018-19) Natural Gas R&D Budget Plan includes research funding for energy efficiency, renewable energy and advanced generation, energy infrastructure (including pipeline safety and energy-related environmental research), natural gas-related transportation, and program administration (Table 3). A research initiative consists of one or more research projects, each of which is designed to resolve issues

associated with a technology or area of science. The Energy Commission's Natural Gas R&D budget allocates funding to CPUC-approved initiatives that are later acted upon by developing specific projects selected through competitive solicitations.

Table 3: FY 2018-19 Proposed Natural Gas Research Budget Plan Summary

Research Areas	Proposed Budget
Energy Efficiency	\$6,000,000
Renewable Energy and Advanced Generation	\$3,000,000
Energy Infrastructure	\$8,600,000
Natural Gas-Related Transportation	\$4,000,000
Program Administration	\$2,400,000
TOTAL	\$24,000,000

Source: California Energy Commission

Response to CPUC Resolution G-3484

As requested by the CPUC, the Energy Commission has reviewed the unspent funds in the Public Interest Research Development and Demonstration Natural Gas Subaccount to identify the funds no longer available for expenditure under future grants or contracts. The Energy Commission has budget authority for a six-year fund life, including two years to encumber funding and an additional four years to liquidate. After the two-year encumbrance cycle, an agreement term can be up to four years before the funds are liquidated and unusable for that agreement. While the Research and Development Program has been successful in allocating all annual funding, it is common for some of these agreements to complete activities under budget with an amount of funds being unspent in the six-year cycle. In rare cases, work on a project is stopped by the Energy Commission before the term end date for various reasons, including challenges with finding replacement host sites for projects and unsatisfactory interim results on projects. The Energy Commission has identified \$1.96 million in unspent funds as of fiscal year 2016-2017. Because the unspent funds would amount to one to two projects, the Energy Commission will not request the \$1.96 million as a supplement to the FY 2018-19 proposed budget and will instead make a request in a future budget cycle when a more substantive amount of unspent funds has accumulated.

Energy Efficiency Research

Energy efficiency continues to be important in reducing energy demand and greenhouse gas emissions in buildings and the industrial sectors. Energy efficiency is the strategy of first choice since it is the least expensive, most reliable, and most environmentally sensitive means for minimizing society's contribution to climate change.⁴⁷ Sustained development, enhancement,

⁴⁷ *California Energy Efficiency Strategic Plan, 2011 Update*: <http://www.cpuc.ca.gov/NR/rdonlyres/D4321448-208C-48F9-9F62-1BBB14A8D717/0/EEStrategicPlan.pdf>.

deployment, and operation of better energy efficiency-related technology for existing and planned buildings, and industrial plants and processes, are essential to meet the state's energy efficiency and greenhouse gas reduction goals. California's pursuit of a low-carbon future will hit a critical milestone in 2030. To reach the targets for energy efficiency and greenhouse gas (GHG) emission reductions required by Senate Bill 350 and Senate Bill 32 (Pavley, Chapter 249, Statutes of 2016), the pace of technological progress must increase exponentially, especially for industries and facilities that are high emitters of GHG emissions. In 2015, the industrial sector emitted roughly 23 percent of total GHG emissions in California and the building sector emitted less than half of this amount or about 11 percent.⁴⁸

Past energy efficiency research has supported, tested and demonstrated precommercial technologies, strategies, and tools to reduce energy use in buildings and the industrial sectors.

For the building sector, the focus has been on envelope tightening, water, heating efficiency, evaluating and testing solar thermal applications, heat recovery for hot water systems, gas-fired heat pumps and high-efficiency natural gas food service appliances. A solar thermal heat pump that combined a solar thermal energy collector and an absorption heat pump to produce hot and chilled water simultaneously was tested at large hotel in Southern California. The goal was to reduce natural gas use to produce domestic hot water for showers, laundry and kitchen and chilled water for the absorption chiller. The system reduced natural gas use by 30 percent to 50 percent for heating water. Another research project demonstrated natural gas saving retrofits associated with the food service industry (for example restaurants and cafeterias). The project replaced cookline equipment with high efficiency griddles, pots, ovens, steam kettles, conveyor broilers and fryers. Retrofits are saving restaurants between \$3,000 and \$13,000 in energy costs annually, and contribute to reducing the impact of the Aliso Canyon natural gas storage facility by alleviating natural gas demands.

For the industrial sector, this research has included developing and testing advanced burner designs that can achieve high energy efficiency while lowering NO_x emissions, testing heat recovery methods that allow for secondary uses such as water heating or chilling, testing advanced drying processes coupled with sensors to prevent over drying and excess natural gas use and use of solar thermal for hot water production. For example, a project that focused on an innovative system that extracts waste heat from biogas to electricity generators and then uses the waste heat for water heating and chilling in cheese making reduced both natural gas (7 percent reduction) and electricity use (65 percent reduction). This technology is being demonstrated at Gallo Cattle Company in the Central Valley town of Atwater. Another project is demonstrating an indirect gas-fired dryer for bulk foods processing. This technology is being demonstrated at Inland Empire Foods in Riverside and has the potential to improve the efficiency of bulk foods dryer by more than 75 percent and reduce natural gas consumption by at least 60 percent.

⁴⁸ <https://www.arb.ca.gov/cc/inventory/data/data.htm>.

Some of these technologies, especially those associated with food service, show great promise with a high potential for commercial adoption. But others, especially in the industrial sector need further testing, demonstrations and/or other strategies to bring down equipment costs, ensure performance reliability and product acceptability, and to reduce technical and economic risk.

Due to the greenhouse gas reduction and energy efficiency targets for 2030 and beyond, the primary focus of the FY 2018-19 budget plan for energy efficiency research is on the industrial sector with a secondary focus on the building sector that could benefit from similar technology advancements.

The proposed research budget for energy efficiency is \$6 million (Table 4). Research will be coordinated with other program areas, as appropriate.

Table 4: FY 2018-19 Proposed Natural Gas Research Budget Plan Summary – Energy Efficiency

Program Area – Energy Efficiency	Proposed Budget
Proposed Research Initiatives: <ul style="list-style-type: none"> ▪ Reduce Natural Gas Use for GHG Emission Intensive Industries/Facilities 	\$6,000,000

Source: California Energy Commission

Energy Efficiency Program Goals

- Conduct research, development, and demonstration to increase energy efficiency while reducing operating costs, natural gas use and greenhouse gases and other air emissions (for example low NOx)
- Advance energy-efficient technologies that support decarbonization
- Develop and demonstrate affordable energy-efficiency technologies, processes, and strategies
- Maintain or increase productivity and increase the industry’s competitiveness in the global market
- Commercialize technologies with broad market penetration

Project 1: Reduce Natural Gas Use for GHG Emission Intensive Industries/Facilities

The Issue

This initiative focuses on industries/facilities in California that have high natural gas consumption and are very GHG emission-intensive. This sector includes many facilities that are required to report on annual facility level GHG emissions to the California Air Resources Board because they emit more than 10,000 metric tons of GHG emissions annually. Those that emit more than 25,000 metric tons are known as “capped facilities” are subject to California’s GHG Cap and Trade Program and must reduce emissions or purchase allowances in quarterly auctions. The cap on how much GHG emissions can be emitted annually will shrink 3 percent

annually from 2015 to 2020 and is expected to shrink more quickly each year from 2020 to 2030 to move California toward the goal of reducing GHG emissions to 40 percent below the 1990 level by 2030. To help achieve these emission reduction goals, research is necessary to develop and demonstrate technologies that could significantly reduce natural gas and GHG emissions and generate cost savings. In addition, the focus is on technologies with the potential for broad market penetration to multiple types of industries and facilities in the mid to long-term time frame. The most affected sectors include petroleum refining, oil and gas extraction, glass and cement, food production, paper, chemicals and allied products, metals and dairies.⁴⁹⁵⁰ Furthermore, these industries are risk-averse and want verified performance, economic and reliability data before deciding to invest in major equipment and systems.

The Research

This initiative focuses on industrial and other facilities that emit more than 10,000 metric tons of greenhouse gas emissions annually. Research focuses on developing and demonstrating technologies that could reduce natural gas, GHG and other air pollutants (such as NO_x) cost effectively. Potential research could include the following or integrate multiple approaches:

- Test advanced non-thermal water removal technologies
- Test alternatives to steam for sterilization and process applications
- Test or demonstrate highly efficient combustion systems and fuel-flexible industrial combustion systems
- Develop innovative, cost-effective systems to recover waste heat
- Develop advanced sensors, controls and models that reduce energy intensity
- Develop and test advanced materials and catalysis for high-temperature and harsh environmental conditions
- Develop technologies that reduce natural gas use with potential for zero or near-zero NO_x emissions compared to current equipment.
- Assess and deploy best available emission reduction technologies that also result in reductions in natural gas use and greenhouse gas emissions

The Benefits

- **Technology Potential.** The industrial sector uses roughly 37 percent of natural gas consumed in California and contributes 23 percent of greenhouse gas emissions. As a result, successful demonstrations can help reduce technology risk by providing information on performance and benefits and can increase the likelihood of implementation, especially if it increases the potential for global competitiveness.
- **Market Connection.** In California, there are approximately 394 industrial facilities that emit more than 10,000 metric tons of carbon dioxide annually with 358 industrial facilities that emit more than 25,000 metric tons. As these industries must reduce greenhouse gas emissions, identifying cost effective solutions will help maintain the competitiveness of these industries and reduce GHG leakage potential. Leakage is defined by the California Air Resources Board as industries/companies that reduce GHG

49 <https://www.arb.ca.gov/cc/capandtrade/allowanceallocation/v2017allocation.pdf>.

50 <https://www.arb.ca.gov/cc/capandtrade/allowanceallocation/v2016allocation.pdf>.

emissions within California but is offset by an increase in GHG emissions outside of California due to relocation.⁵¹

- **Energy and Cost Savings.** The amount will depend on the industry, current energy use and equipment to be replaced, but funded technologies are expected to reduce natural gas use and cost by at least 10 percent.
- **Environmental Benefits.** The amount will depend on the industry and the amount of natural gas savings, but funded technologies are expected to reduce natural gas use and GHG emission by at least 10 percent, with the potential of reducing oxides of nitrogen emissions and other air contaminants.
- Responds to the CPUC resolutions G-3519 and G-3527 which instructed the Energy Commission to focus on research solutions to help the emissions intensive industries/facilities:
 - *G-3519:* “...plan to leverage existing research to target industries and facilities that could benefit from research advancements, including entities covered under the Air Resources Board (ARB)’s Cap-and-Trade program, as well as industries that are emissions intensive and trade exposed (EITE), identified in ARB’s past and ongoing leakage studies. The intent within the previous resolution was consistent with state goals under AB 32. We continue to press the CEC to do so in the current resolution.”
 - *G-3527:* “...call upon the CEC to identify and target specific research needs and address R&D challenges of high-, medium-, and low-leakage risk industries. Within energy efficiency, this may require a closer examination of the operating environments within heavy industry and manufacturing that present opportunities for creating higher overall system efficiencies.”

Renewable Energy and Advanced Generation

The Renewable Energy and Advanced Generation research area conducts research addressing cost and other barriers to increasing market penetration of renewable energy, including renewable gas, distributed generation (DG), and combined-heat-and-power (CHP) systems. Technologies of focus include hybrid, fuel-flexible, high-efficiency, and low-emission DG and CHP systems for use with natural gas or renewable gas fuel. Technologies such as thermally driven cooling and thermal energy storage are also supported which allow CHP systems to operate flexibly and reduce peak loads. Finally, this research area includes technology advancements for the conversion, cleanup, and upgrading of biomass resources (that is, forest wood waste, landfill gas, or anaerobic digester gas) to renewable natural gas.

⁵¹ Leakage is a reduction in emissions of GHG within California that is offset by an increase in emissions of GHG outside of California. (<https://www.arb.ca.gov/cc/capandtrade/meetings/073012/emissionsleakage.pdf>)

Renewable energy resources are essential for reducing greenhouse gas emissions and achieving state statutory energy goals. Solar, wind, hydroelectric, and geothermal are abundant and well-known renewable resources that constitute nearly 90 percent of the renewable electricity in California. The remaining 10 percent of renewable electricity is produced from biomass resources, which along with being renewable have the added benefits of diverting waste from landfills and reducing methane emissions, a powerful short-lived climate pollutant. Reducing short-lived climate pollutants, in particular, has been identified as an opportunity for immediate, significant reductions in GHG emissions in California.

The Energy Commission has funded research related to biomass use in the Natural Gas and EPIC research programs. This research has examined producing biogas from various biomass resources (forest and agricultural wood wastes, dairy waste, food waste), using biogas to produce renewable electricity, and developing the technologies that clean and upgrade biogas to renewable natural gas for pipeline injection and vehicle fuel applications. Most of this research, however, has focused on using biogas at commercial-scale facilities such as landfills and large dairies. Similar programs, such as the California Department of Food and Agriculture's Dairy Digester Research and Development Program, have also focused funding on large facilities. There is a need to research technologies that can benefit small dairies, livestock, and other small farms which would allow them to convert their biomass resources into renewable energy for electricity generation and transportation fuel where economical.

Advanced distributed generation systems are also considered a key distributed energy resource that could contribute to achieving state statutory energy goals. Distributed generation systems have been employed around the state to produce reliable, on-site power for customers in all sectors for many years. However, just because these systems are mature does not mean there isn't room for improvement. The Energy Commission has funded research related to making distributed generators cleaner, more efficient, and fuel-flexible. Other research has focused on combined-heat-and-power configurations to recover waste heat and reduce greenhouse gas emissions. As energy systems become smarter, there is a need to adapt these systems to match the functionality of modern distributed energy resources. The addition of advanced features such as remote controls, automation, flexibility, and islanding/black-start⁵² capability would allow distributed generators to function as an integrated component of a modern energy system. There is an opportunity to introduce these functionalities to maximize efficiency, cost-effectiveness, and greenhouse gas emission reductions. These opportunities are targeted in the research initiatives described below.

The proposed research budget for renewable energy and advanced generation is \$3 million (Table 5).

⁵² Islanding is isolating the power source and black start is restoring an electric power station or part of the grid to operation with relying on the external electric power transmission network.

**Table 5: FY 2018-19 Proposed Natural Gas Research Budget Plan Summary –
Renewable Energy and Advanced Generation**

Program Area – Renewable Energy and Advanced Generation	Proposed Budget
Proposed Research Initiatives: <ul style="list-style-type: none"> ▪ Central Valley Agricultural Waste Resources to Energy ▪ Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities 	\$3,000,000

Source: California Energy Commission

Renewable Energy and Advanced Generation Program Goals

Reduce barriers and increase the amount of renewable energy by:

- Advancing the development and market availability of clean and efficient DG and CHP technologies.
- Developing cost-effective hybrid generation, fuel-flexible, energy-efficient, and low-emission gas DG technologies for alternative fuels, including renewable gas and natural gas.
- Developing and demonstrating diversified applications of advanced generation technologies that use renewable gas.

Proposed Research Initiatives

Project 1: Central Valley Agricultural Waste Resources to Energy

The Issue

SB 1383, signed into law in 2016, calls for dramatic reductions in short-lived climate pollutants (SLCP) compared to 2013 levels by 2030. Specifically, California must reduce emissions by 50 percent for anthropogenic black carbon, 40 percent for methane, and 40 percent for fluorinated gasses. SLCP refers to a subset of greenhouse gases which have both high global warming potential and relatively low atmospheric lifetime. SLCP emission reductions can make an immediate beneficial impact on climate change.

Central Valley farms produce such a high volume of agricultural residues that the handling and disposal of these residues are problematic. These farm residues include orchard and vineyard pruning's and tree and vine removals; nut shells and hulls; and residues from field, cover crops, and vegetables crops. Disposal through open pile burning contributes significant particulate emissions to an already pollution-burdened region with many disadvantaged communities. Projections indicate that emissions from open burning will continue to rise without a cost-effective alternative. Disposal and management of such residues in the Central Valley are further impacted by issues such as reductions in the availability of biomass power plants and limitations in agricultural burning. While the San Joaquin Valley Air Pollution Control District (SJVAPCD) has the toughest rules in place on agricultural burning, it is considering a rollback of

the rules that limit agricultural burning because of the glut of biomass resulting from the aforementioned events. In the meantime, the SJVAPCD increased the fine for agricultural burning to \$750 per acre; unfortunately, some farmers are opting to pay the heavy fine. A recent SJVAPCD summit focused on the urgent need to find cost-effective alternatives to openpile burning, including bioenergy.

In addition to agricultural residues, livestock manure, primarily from cattle, is the largest source of methane emissions in California, responsible for roughly 25 percent of annual methane emissions. The California Air Resources Board *Short-Lived Climate Pollutant Reduction Strategy* identifies dairy manure management as an opportunity for significantly reducing methane emissions.⁵³ There exists significant potential to capture and economically convert this methane into on-site generation and transportation fuel, thereby reducing dependence on fossil fuel.

The primary method for capturing and converting methane to energy is via anaerobic digestion. Anaerobic digestion is a complex biochemical process in which organic materials are placed in an oxygen-free environment to decompose into biogas, water, and solids. The biogas (primarily carbon dioxide and methane) can be used to create renewable heat, renewable electricity, or renewable natural gas or a combination of the three. Anaerobic digester technology has been demonstrated at several large dairy farms in California. However, economic payback of these technologies has a large scale-dependency – in other words, these systems are far less economical at small dairy and livestock farms, a number of which are found in the Central Valley. As a result, recent grant programs have focused on large dairy farms. There is a need to develop and demonstrate systems that can operate economically at smaller scale to capture organic waste from smaller farms such as livestock facilities with fewer than 1,000 heads and convert it to biogas or renewable natural gas.

Agricultural residues discussed above could be used to produce renewable natural gas that could be made available for onsite generation or transportation applications where economical. Converting these residues to energy through a controlled process would also reduce pollutant emissions, such as black carbon, compared to open pile burning with positive implications on the overall health and well-being of Central Valley communities.

The Research

This initiative proposes R&D that will support precommercial technologies and strategies to enable effective and economic energy conversion of agricultural residues in the Central Valley as an alternative to open pile burning and flaring. In particular, R&D will emphasize conversion of agricultural organic wastes to biogas and biomethane or RNG production focusing on development strategies that will make such bioenergy conversion economic for smaller farms. CPUC Decision G-3527 recognized that “advancement of biomethane research could not only mitigate short-lived climate pollutants, but also create new energy pathways for underserved communities in the San Joaquin Valley.”

⁵³ California Air Resources Board. *Revised Proposed Short-Lived Climate Pollutant Reduction Strategy*. 2016. <https://www.arb.ca.gov/cc/shortlived/meetings/11282016/revisedproposedslcp.pdf>.

Possible technologies and strategies include, but are not limited to, the following:

- Preprocessing steps that improve handling and conversion efficiency of agricultural biomass matched with improvements in conversion technology.
- Development, demonstration and overall improvement to thermochemical conversion approaches for non-manure agricultural residues to renewable natural gas cost-effectively.
- Preengineered systems capable of low-cost deployment at a range of scales in Central Valley farms.
- Innovative strategies such as collecting waste from several small farms to transfer to a central bioenergy plant to improve cost-effectiveness.
- Pretreatment steps (that is solids separation, hydrolysis) before anaerobic digestion; improvements to the anaerobic digestion process (such as mixing or pumping) that increases biogas quality; codigestion of organic wastes; and possibly alternative processes such as thermal hydrolysis.
- Combined heat-and-power systems optimized for biogas operation.

Projects must demonstrate a “whole system approach” from feedstock to end use. End uses must prioritize energy production for the most economical use, potentially including renewable electricity, renewable natural gas for pipeline injection, or renewable natural gas for vehicle fuel, depending on the location of the feedstock. Technologies should focus on improving efficiency, reducing costs, and reducing environmental impact compared to conventional systems and should be demonstrated at a farm in the Central Valley of California.

The Benefits

- **Energy Sector.** The technologies developed and demonstrated in this initiative are intended for use at small dairy and livestock farms in California. These technologies would allow these farms to produce biogas for on-site heat and power production, offsetting natural gas and electricity demand from utilities. The biogas can also be upgraded to renewable natural gas for generation or transportation applications, if economically feasible at that location.
- **Technology Potential.** According to U.S. Department of Agriculture census data, half of all dairy farms in California have herd size of fewer than 1,000 cows.⁵⁴ These farms account for roughly 350,000 of California’s 1.8 million dairy cows (approximately 20 percent). Assuming 200 kilowatts (kW) of electricity per 1000 cows, these small farms represents about 70 MW of renewable energy potential in California. This number does not include renewable energy potential from small beef cattle, hog, sheep, poultry, and other small farms.
- **Market Connection.** According to the U.S. Environmental Protection Agency AgSTAR database, there are 16 operational dairy digester projects in California. Of these, only

⁵⁴ 2012 *Census of Agriculture*. United States Department of Agriculture. 2014.
https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/California/.

three are located at farms with fewer than 1,000 cows.⁵⁵ Improving biogas generation technologies would help increase these numbers to realize the potential benefits.

- **Energy and Cost Savings.** Increased biogas use at small dairy and livestock farms could significantly offset the fossil fuels that normally provide the heat, electricity, and vehicle fuel used. Specifically, biogas used on-site would offset the typically natural gas-fueled electricity, propane-fueled heating, and diesel vehicle fuel, with the latter two presenting even higher cost savings. Furthermore, these energy and cost savings have the potential to significantly impact small farms where costs are higher per pound of product produced.
- **Environmental Benefits.** As stated above, nearly 20 percent of the dairy cows in California are located at small farms with herd sizes of fewer than 1,000 cows. This number accounts for about 4 percent of statewide methane emissions, or one-tenth of the required reduction to meet the goals set by the Super Pollutant Reduction Act. In addition, reductions in open pile burning will result in criteria air pollutant reductions of NO_x and black carbon (particulate matter), improving air quality in the most pollution burdened air basin in California.

Project 2: Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities

The Issue

Assembly Bill 32 and the Governor's Clean Energy Jobs Plan set aggressive goals for advanced generation technologies, including clean distributed generation (DG), combined heating and power (CHP) and combined cooling, heating and power (CCHP) for California. Despite these drivers, DG, CHP, and CCHP systems have seen minimal growth in recent years. For example only 3,086 MW of CHP capacity has been procured by IOUs since 2010 versus a goal of 6,500 MW by 2030 as outlined in the Governor's Clean Energy Jobs Plan.⁵⁶

In addition, the recent passage of Senate Bill 350 calls for a significant increase in renewable energy generation in California – specifically 50 percent of retail electricity in California by 2030. To achieve these goals, large amounts of intermittent renewable energy (such as solar PV and wind) will be added to California's electricity mix. In recent years, increased penetration of solar PV has caused large diurnal swings in energy load. To manage this load at the utility-scale, smarter grid management practices and advanced technologies such as large-scale energy storage and fast ramping power plants (peaker plants) have been employed.

Recent extreme weather events, such as wildfires or drought, have also impacted power generation and distribution and, in many cases, resulted in wide-scale power interruptions that impacted critical facilities (for example hospitals and fire and police stations). As renewable energy penetration grows to meet California's clean energy goals and as the rate of extreme

⁵⁵ *Livestock Anaerobic Digester Database*. AgSTAR. 2016. <https://www.epa.gov/agstar/livestock-anaerobic-digester-database>.

⁵⁶ *Tracking Progress – Combined Heat and Power*. California Energy Commission. 2017. http://www.energy.ca.gov/renewables/tracking-progress/documents/combined_heat_and_power.pdf.

weather events increase, resilience needs to be built in to demand energy response deployment and operation.

Similar to the utility-scale systems, distribution-scale systems are increasingly integrating renewable generation (e.g. solar PV) with energy storage and traditional DG systems (such as smartgrids and microgrids). Grid system operators and microgrid operators need DG systems that can operate flexibly and resiliently in extreme events such as wildfires.

The Research

This initiative funds precommercial technologies and strategies that address the technical and economic barriers related to deploying clean and efficient DG, CHP, and CCHP systems as a key power enabler in high-fire-risk regions and at critical facilities, and as a key component of an integrated modern energy system. At minimum these systems should be capable of black start and grid islanding. This means the systems can start without the need of grid power and continue to operate in order to restore power to a critical facility. In addition to these capabilities, precommercial technologies should include other enhancing features.

Possible precommercial technologies and strategies include, but are not limited to, the following:

- Systems that are capable of fast ramping (respond to external signals and rapidly adjust electrical output) and other functionalities needed to respond and provide needed power during fire and other catastrophic events. These may include clean and efficient DG and CHP systems, including biogas-fueled systems which maintain high efficiency over a large operating range (high turndown ratio)
- Advanced DG and CHP systems built specifically for integration with renewable energy, energy storage, and microgrid controllers particularly in critical facilities located in high fire hazard severity zones
- CHP systems with multiple operating modes based on external stimuli (such as a CCHP system that switches between heating or cooling, or a CHP system that switches between generator-driven heating and electric heating, based on building loads or in response to extreme events)
- Advanced DG (including biogas-fueled DG and CHP) system controls that allow increased amount of renewable generation, while improving reliability in high fire risk regions and critical facilities

Projects funded by this initiative are expected to demonstrate a “whole system approach.” For example if the goal of the project is to combine DG and battery energy storage into an integrated system, actual generation of electricity and storage in batteries must be demonstrated, at least at the bench scale. Technologies should focus on improving efficiency, reducing costs, reducing environmental impact, and improving reliability compared to conventional systems.

The Benefits

- **Energy Sector.** Increased deployment of DG, CHP, and CCHP systems has the potential to reduce statewide consumption of natural gas and provide increased reliability, flexibility, and power quality, reduce transmission and distribution losses, and reduce transmission congestion on the local electric grid.
- **Technology Potential.** There exists a large potential market for DG, CHP, and CCHP systems in the commercial, light industrial, institutional, and multifamily residential sectors. A report produced for the Energy Commission by ICF International identified CHP generation potential for existing facilities in the above-listed sectors of 2,766 megawatts (MW), with an additional 531 MW growth expected by 2030.⁵⁷
- **Market Connection.** Small-scale DG, CHP, and CCHP systems allow facility owners to affordably meet their on-site electric and thermal needs while providing energy security and reliability. Possible customers for small DG, CHP, and CCHP systems include:
 - Hospitals.
 - Hotels.
 - Schools.
 - Multifamily dwellings.
 - Commercial buildings.
 - Light industrial facilities.
- **Energy and Cost Savings.** A report produced for the Energy Commission by BEW Engineering and Lawrence Livermore National Laboratory estimates the potential energy and cost savings of the 448 MW of small CHP identified to nearly 155 million therms per year and valued at \$105 million, based on 82 percent penetration in the stated megawatt range. This estimate assumes a 90 percent capacity factor and a commercial cost for natural gas of \$0.68/therm.⁵⁸
- **Environmental Benefits.** There could be improved air and environmental quality and reduced climate change impacts through reduced natural gas consumption, greenhouse gas emissions reductions, and water savings.

⁵⁷ *Combined Heat and Power: Policy Analysis and 2011-2030 Market Assessment*. ICF International for the California Energy Commission. 2012. CEC-200-2012-002 <http://www.energy.ca.gov/2012publications/CEC-200-2012-002/CEC-200-2012-002-REV.pdf>.

⁵⁸ BEW Engineering and Lawrence Livermore National Laboratory for the California Energy Commission. 2011. *Geographic Information System-Enabled Renewable Energy Analysis Capability Project Final Report*. CEC-500-2011-026 <http://www.energy.ca.gov/2011publications/CEC-500-2011-026/CEC-500-2011-026.pdf>.

Energy Infrastructure

The infrastructure providing natural gas to customers is vast and covers most of the state. It includes producing wells, treatment facilities, transmission lines, compressor stations, distribution lines, meters, and small pipes inside homes and buildings. Natural gas is a highly combustible gas, contains toxic compounds and has a very potent greenhouse gas, methane, as one of its main components. California's natural gas wells and pipelines face risks that could cause potential damage or catastrophic events. The massive natural gas leak at Aliso Canyon shined a light on California's aging natural gas infrastructure. Furthermore, five years of extreme drought also exacted a toll on transmission pipelines, prompting the Energy Commission to begin research on drought-induced subsidence impacts on natural gas pipelines. Events such as San Bruno and Aliso Canyon are reminders of the importance that public safety, public health, and greenhouse gas emissions considerations must have in any research portfolio covering natural gas. Further, climate change would exacerbate existing risks such as exposing natural gas infrastructure directly or indirectly to wildfires, landslides, coastal and inland flooding, and ground subsidence due to over drafting of groundwater. Finally, the natural gas system must evolve substantially by lowering the carbon or greenhouse gas footprint if it is going to be part of the solution to comply with the 40 percent GHG reduction mandate by 2030 and the 80 percent reduction goal by 2050.

The Energy Commission has funded research in energy infrastructure assessing the current vulnerability of the natural gas system to prevent damages from excavation and other risks. This work includes developing and demonstrating risk management tools and monitoring technologies to evaluate the integrity of the natural gas system to prevent public safety issues or catastrophic failures. The Energy Commission has also funded research on:

- Methane leaks from wells to final consumption (e.g., emissions from homes).
- The identification of super emitters, indoor air quality implications on using natural gas for cooking and other applications.
- Safety associated with the combustion of different blends or types of natural gas (e.g., using blends with biomethane).
- Potential safety issues related to ground subsidence in the San Joaquin Valley.
- Potential impacts and adaptation options to climate change.
- Strategies to decarbonize the natural gas system.

Projects are still ongoing, and results are shared with state agencies such as the California Air Resources Board to inform greenhouse gas inventory and other policy goals. The Energy Commission's work on safety and environmental issues is a continuum of projects informing each other. For example, preventing catastrophic failures would also help reduce the methane leaks and identifying leaks can be used to identify potential failure modes. However, from a climate perspective most of the important leaks are not associated with potential infrastructure risks.

This year in the safety area, the Energy Commission proposes to enhance prior work to have an improved inventory and characterization of existing natural pipeline infrastructure by developing and using advanced low-cost sensor technologies to gather, store, and analyze pipeline and storage characteristics (for example materials, age, and manufacturer). This characterization would help prioritize the deployment of expensive safety evaluation technology options developed in past research projects. Another area that will receive attention this year is the modeling the potential for mechanical failures. This modeling will enhance prior and ongoing work on risk assessment modeling. Finally, the Energy Commission proposes to support the development of automated shutoff equipment for natural gas infrastructure to prevent dangerous situations. The ongoing risk assessment would identify where this shutoff equipment should be located.

In the environmental area, the Energy Commission proposes continuation the evaluation of climate risks to support creating the California Climate Partnership with energy utilities as recommended in the *2017 Integrated Energy Policy Report (IEPR)*. In the area of emissions and renewable natural gas via biomethane, for the first time, the Energy Commission is suggesting measurement of methane emissions before and after energy facilities are in place because prior and ongoing work supported by the Energy Commission suggests that the climate benefits of these energy projects may be underestimated. Actual emissions of uncontrolled landfills, dairies, and manure management may be much higher than what is reported in official GHG inventories.⁵⁹

In the long term, it is important to consider energy modeling performed for California, which suggests that to meet the GHG emission targets by 2030 and 2050, natural gas consumption must go down substantially and be a very small fraction of what is consumed today. Therefore, the entire transmission and distribution system may be pressurized to meet a much lower demand in the future. Alternatively, it may be that only parts of the system are necessary to provide service to sectors that still rely on natural gas. Another option to lower the GHG footprint of natural gas is the blending of hydrogen produced using renewable electricity and sustainable bio-methane. This blending would bring other RD&D challenges for safety and environmental concerns. While considering the required transformation of the natural gas system to comply with GHG emission targets, other impacts on the natural gas system such as earthquakes and fires, should also be addressed in future environmental and infrastructure safety research.

The energy infrastructure area includes research associated with infrastructure safety pipeline integrity management, and energy-related environmental and climate issues.

The proposed research budget for energy infrastructure is \$8.6 million (Table 6), with \$5.6 million allocated for natural gas infrastructure safety and integrity research and \$3 million allocated for energy-related environmental research.

⁵⁹ Duren, Riley. Personal communication. NASA.

Table 6: FY 2018-19 Proposed Natural Gas Research Budget Plan Summary – Energy Infrastructure

Program Area – Energy Infrastructure	Proposed Budget
Natural Gas Infrastructure Safety and Integrity Proposed Research Initiatives: <ul style="list-style-type: none"> Technologies for Natural Gas Infrastructure Damage and Failure Prevention Modeling Mechanical Failure Potential Decreasing Failure Consequences -Developing Automated Shutoff Equipment for Natural Gas Infrastructure 	\$5,600,000
Energy-Related Environmental Research Proposed Research Initiatives: <ul style="list-style-type: none"> Measuring the Emissions Benefits of Renewable Natural Gas Fostering Natural Gas Sector Resilience 	\$3,000,000

Source: California Energy Commission

Natural Gas Infrastructure Safety and Integrity

Natural Gas Infrastructure Safety and Integrity Program Goals

- Provide research that results in increased safety and enhanced transmission and distribution capabilities of the natural gas system.

Proposed Research Initiatives:

Project 1: Technologies for Natural Gas Infrastructure Damage and Failure Prevention

The Issue

Safely operating natural gas infrastructure remains a substantial challenge, and damage or failure continues to affect natural gas availability, public safety, and greenhouse gas releases. In November 2017, the California Energy Commission, California Public Utilities Commission (CPUC), California Independent System Operator, and the Los Angeles Department of Water and Power released their fourth energy assessment for Southern California and expressed concern about existing pipeline outages. Recent incidents of pipeline damage on two Southern California Gas Co. (SoCalGas) transmission pipelines have significantly decreased natural gas import capacity to Southern California and exacerbated the potential for shortages. In addition, with the forecasted increase in demand through 2028 and requests for closure of the Aliso Canyon storage facility, safely operating natural gas infrastructure including storage and pipelines will continue to play an integral role in California’s energy system. Ensuring current and future infrastructure meets safety requirements will continue to be a priority moving forward. Properly managing the infrastructure and identifying the greatest risk areas are complicated by the complexity of the system and lack of available data. The system consists of components of

varying materials, ages, locations, depths, manufacturers, and operational characteristics, which are threatened by corrosion, natural forces (for example from seismic or climate change impacts), excavation damage, and incorrect operation.⁶⁰ It is essential to develop and demonstrate inexpensive technologies for pipelines and storage infrastructure to gather relevant field data to help prevent damage and inform emergency response. Deploying these technologies on existing or new infrastructure will allow utilities to better monitor system risks.

Advanced sensors and controls have the greatest potential to transform the aging natural gas system to smart energy infrastructure. Energy Commission started investing in sensor technologies to reduce incidents of excavation damage and the amount of time required to locate assets for engineering, operations, and one-call activities. This includes a Global Positioning System Excavation Encroachment Notification System (GPS EENS) to increase situational awareness of operating excavators and a real-time active pipeline integrity detection (RAPID+) system to detect pipeline degradation. Initial evaluation of the advanced sensors indicates most of the technologies are at a relatively low technology readiness level (TRL), which requires additional research and demonstration before transitioning to deployment and commercialization.

The Research

Building on existing research and advancements in sensors, mobile technology (for example smartphones and tablets), geospatial systems (such as geographic information systems [GIS] and global positioning systems (GPS), and computing infrastructure (for example the “cloud” and Web), this research will focus on developing and using advanced sensor technologies to gather pipeline and storage characteristics to assist utilities in preventing damage or other failure, improve public safety and system integrity, increasing operational efficiencies, and reducing GHG emissions. Possible research includes, but is not limited to:

- Developing and using technologies for automating data capture with advanced sensors to allow utilities to collect field data (such as materials of construction, horizontal and vertical location, pressure, manufacturer, serial numbers, dates manufactured/repaired, and certifications) so utilities are better able to use this information in the future to predict potential failures based on knowledge of equivalent system degradation or manufacturer warnings.
- Proposed research that must address the barriers for the full deployment of these technologies by the utilities. Research should focus on evaluating and demonstrating the technologies under various operating conditions typically found in the field. This requires coordinating with entities that can commercialize these products, demonstrating the technologies at utility sites, and conducting cost-benefit analysis for large-scale deployment of the technology to satisfy program objectives.

⁶⁰ PHMSA. 2014. “Significant Pipeline Incidents by Cause.” http://opsweb.phmsa.dot.gov/primis_pdm/significant_inc_trend.asp.

The Benefits

- **Energy Sector.** The technologies developed and demonstrated in this project are intended to improve safety, reliability, and integrity of natural gas infrastructure.
- **Technology Potential.** Recent advances in advanced sensors, mobile technology, geospatial systems, and computing infrastructure have provided the tools to support next generation technologies for pipeline and storage damage prevention. Deploying these technologies broadly will provide a robust use case to other utility companies and will help prove the value and cohesiveness of integrated technologies.
- **Market Connection.** Despite technological advancements, natural gas operators have diverse approaches to gather data on infrastructure, including paper-based methods to collect and document asset properties and environmental conditions. Utilities could use the proposed and past technologies to automate data capture and allow the data to be accessed in near real-time, including for emergency response.
- **Energy and Cost Savings.** The technologies will result in the ratepayer benefit of improved public safety. Moreover, the technologies will decrease the probability of an incident through real-time data collection and the consequence of an incident through situational awareness during emergency response. A secondary ratepayer benefit of lower cost operations will also be achieved.
- **Environmental Benefits.** Natural gas is an important tool in the suite of GHG emissions reduction options. Reducing the probability of unprecedented pipeline and storage outages by applying advanced sensor technologies will increase usage of natural gas, and will help reduce direct and indirect GHG emissions.

Project 2: Modeling Mechanical Failure Potential

The Issue

Material, weld, and equipment failures account for 53 percent of the total pipeline incidents. The slow progression of mechanical failures such as corrosion, and stress cracking is always challenging to predict because of the variety of conditions that can result in these failures. While some work has begun to develop risk assessment models, more needs to be done to take full advantage of material science and the growing amount of data on system components. This research will build on existing work to develop risk assessment methods by integrating more diverse sources of knowledge and information, including the understanding of failure processes, and by applying data collected from real-time sensors and monitoring devices, either already deployed or to be deployed, to develop more accurate failure predictions. This predictive tool and modeling can be used for pipelines and storage.

The Research

The slow progression of mechanical failures is challenging to predict. With greater availability of material and site data, predictive models can be used to predict these failures systemwide. As the data collected on their systems increase, IOUs could use a predictive tool to better

assess potential failures and take actions before a catastrophic failure. Possible projects in this initiative may include:

- Developing and deploying a predictive model/tool by accounting for possible threats to:
 - Evaluate the probability of failure of the natural gas network, including storage systems.
 - Determine the highest threat of failure.
 - Develop the most appropriate mitigation strategy by conducting cost/benefit analyses.
 - Find optimal preventive maintenance and replacement decisions.

The project will involve partnering with major natural gas companies in California to validate the predictive tool for assessing corrosion and mechanical failure threats due to potential threats identified by the Pipeline and Hazardous Materials Safety Administration (PHMSA). The predictive models must be based on the time-dependent failure characteristics of natural gas transmission and distribution pipelines and storage systems. The research should focus on developing more accurate models and customizing and validating the method for California pipelines. Furthermore, it will help integrate information and data generated from this project, such as material types, pipe sizes, operating pressures, age, and so on.

The Benefits

- **Energy Sector.** Recent pipeline failures and storage leakage incidents in California have resulted in injury, fatalities, and environmental damage. The technology principle benefit is to prevent safety hazards. Additionally California natural gas users and utilities benefit through avoidance of gas delivery disruptions and safety related consequences.
- **Technology Potential.** Utilities could use the proposed predictive model to predict future pipeline and storage failures, determine the highest threat of failure on each segment, and take mitigation actions before a catastrophic failure.
- **Energy and Cost Savings.** Pipeline failures and storage leakage incidents can result in shut downs and increased energy costs. Therefore, a failure prediction method that can assist natural gas companies in anticipating threats and taking timely corrective actions will benefit ratepayers both by increasing their safety and ensuring reliable supply.
- **Environmental Benefits.** Early prevention and detection of failure will minimize methane leaks and hence reduce GHG emissions.

Project 3: Improving Automated Shutoff for Natural Gas Infrastructure

The Issue

Natural disasters, mechanical failures, operational errors, and external impacts can damage gas infrastructure, resulting in small to catastrophic natural gas leaks. Automatic shut-off devices, such as excess flow valves, provide critical safeguards to limit releases. An important aspect of pipeline safety includes greater use of condition monitoring. Monitoring technology with remotely operated valves would provide more rapid response from a central control location. Existing valves could be equipped with a control device that automatically triggers the actuator

and shuts off the flow of natural gas in the event of a large pressure drop. Furthermore, many of these valves can provide routine pressure control to safeguard against exceeding the maximum pressure of the pipeline.

While many of these technologies are well developed for transmission pipelines, much research can be done to explore innovations that are applicable to the distribution system. Upgrading or retrofitting valves on the distribution system with remote-control and automatic shutoff valve technology may provide gas control operators with greater flexibility and shorter response times if it becomes necessary to close a valve or valves quickly in the event of an emergency, such as an earthquake or fire.

The Research

This research proposes to develop, test, and demonstrate automatic shut off technologies to limit the consequences from breaks or ruptures caused by impacts, high pressures, or other causes. Possible projects include developing fast-actuating shutoff valves, regulator equipment, monitoring and automated control of shutoff valves, or other innovative technologies for both pipelines and storage.

The Benefits

- **Energy Sector.** The technologies developed and demonstrated in this initiative are intended for use on natural gas pipelines and the natural gas storage facilities.
- **Technology Potential.** California has a large gas transport infrastructure that is close to urban areas where protection is needed.
- **Environmental Benefits.** Catastrophic natural gas explosions and fires can be a large source of carbon emissions in California. Large methane leaks are also a source of GHG. If adopted, these technologies could help reduce the chances of catastrophic fires, therefore reducing black carbon emissions and the release of large amounts of methane.

Energy-Related Environmental Research

Energy-Related Environmental Research Program Goals

- Develop cost-effective approaches to evaluating and resolving environmental effects of energy production, delivery, and use in California; explore how new energy applications and products can solve or reduce environmental problems; identify vulnerabilities of the energy system to climate change; and develop cost-effective approaches to ensure reliable energy services.

Proposed Research Initiatives:

Project 1: Measuring the Emissions Benefits of Renewable Natural Gas

The Issue

Renewable natural gas (biomethane) could become a zero-emission or very-low-emission greenhouse gas (GHG) emission fuel in California and substantially help reduce GHG emissions from major sources of methane such as dairies (manure management), landfills, and wastewater treatment plants. An additional opportunity exists for switching existing combined heat-and-power facilities to producing renewable natural gas (RNG) due to air quality

regulations in wastewater treatment plants. The gas could be used on-site to generate heat or electricity or both, to be injected into natural gas pipelines, and be used for mobile applications. The climate benefits of GHG reductions are calculated using standard methods that have been developed by extrapolating from relatively few measurements of actual emissions. The processes involved in the generation and final release of methane and nitrous oxide to the atmosphere are highly complex. Field and modeling studies can produce estimates of GHG emissions that are widely different from what is estimated using accepted regulatory methods. In addition, the air quality implications are still not well understood. For all of these reasons, the actual climate and air quality benefits of RNG projects are not certain. In addition, many of the RNG projects are located in disadvantaged communities, where air quality and public health are of primary concern. Evidence shows reduction of odor complaints after energy projects are implemented when they operate properly and reduce methane emissions.⁶¹ Actual emissions reductions can be confirmed and quantified by emissions measurements in the field.

The Research

The research will involve measuring methane and other air pollutant emissions at site(s) before and after energy projects are implemented to generate RNG at those sites. Another possibility is measuring sites that are very similar to one with RNG project already implemented. In this case, the sites should be similar in feedstocks, RNG generation capacities and other characteristics. However, there will be a preference for conducting measurements at the same site, before and after project implementation. The target emissions include methane, nitrous oxide, and volatile organic compounds (VOCs) and other criteria pollutants. The measurements should be made multiple times both before and after to estimate annual emissions instead of one-time measurements, because emissions can be temporarily variable.

The Benefits

- **Technology Potential.** The measurement methods could inform the development of standard approaches to track the GHG benefits of renewable natural gas projects and improve emissions estimates for these types of projects.
- **Environmental Benefits.** This research will help the Energy Commission and other agencies pursuing energy recovery projects at dairies or landfills better estimate greenhouse gas and air quality impacts of the projects. Research will also provide baseline emissions from RNG projects, which currently have not been established.

⁶¹ Duren, Riley. Personal communication. NASA.

Project 2: Fostering Natural Gas Sector Resilience

The Issue

California's climate leadership includes integrating climate adaptation into planning and investment decision-making, "ensuring that people, communities, and natural systems are able to withstand the impacts of climate disruption."⁶² To support adaptation efforts, the California Energy Commission has been a leader in funding research that develops regionally specific climate scenarios with high spatial and temporal resolution for several parameters for the energy system. These scenarios have been adopted as a basis for adaptation planning by the state⁶³ and made publicly available through Cal-Adapt (cal-adapt.org), an interactive website tailored to conveying climate-related risks in a manner that supports energy sector resilience. For several years, the state of California has been working to foster energy sector resilience through such efforts as including a climate adaptation chapter in *the Integrated Energy Policy Report* (IEPR), establishing an Energy Sector Adaptation Working Group headed by Commissioner Liane Randolph of the CPUC and Chair Robert B. Weisenmiller of the Energy Commission, and initiating outreach efforts associated with Cal-Adapt.

More recently, the 2017 IEPR recommended to "explore establishing a California Partnership for Energy Sector Climate Resilience." This partnership, as articulated by SoCalGas, would recognize that "every region of California must be considered and engaged" for the state's resilience efforts to be successful and cost-effective. The 2017 IEPR also recommended consideration of climate resilience metrics to help track California's resilience action and successes.

Another outcome of multiple Energy Commission workshops held in 2017 was repeated indication by investor-owned utilities (IOUs) that they must be involved in identifying and designing research efforts to provide resilience strategies for their energy systems. This level of involvement requires collaboration before the release of requests for proposals.

The Research

Energy sector resilience is a young and rapidly evolving field, and little is known regarding best practices for designing, implementing, or tracking the success of natural gas resilience strategies. The overarching goal of this research is to provide a scientifically sound basis for designing, implementing, and tracking natural gas resilience strategies. Moreover, this research will ideally provide a test case of close collaboration with IOUs to develop research and actions. California's natural gas IOUs are invited to collaborate in developing a call for proposals, to ensure the funded research is responsive to their needs and concerns. The research would provide crucial support to the California Partnership for Energy Sector Climate Resilience. Based on input from IOUs voiced in public Energy Commission workshops in 2017, specific research goals might include some or all of the following:

⁶² <http://resources.ca.gov/climate/safeguarding/>.

⁶³ *Planning and Investing for a Resilient California: A Guidebook for State Agencies* (2017). Prepared by the Governor's Office of Planning and Research with the guidance and input of the Technical Advisory Group formed under direction of Executive Order B-30-15. <http://opr.ca.gov/planning/icarp/resilient-ca.html>.

- Developing metrics to assess and track progress in natural gas system resilience.
- Identifying what scenarios, including but not limited to extreme events that are most important for stress-testing the natural gas system, with attention to infrastructure as well as operational considerations and interconnectedness with other critical systems.
- Developing methods for integrating resilience investments into cost-benefit analyses.
- Conducting potential case studies to pilot test methods.

The Benefits

- **Energy Sector.** This research will benefit natural gas IOUs and other natural gas sector representatives by providing, in response to their input, determining extreme events relevant to the natural gas sector as well as system hot spots in the context of climate-related risks. This information may be used to guide adaptation planning in the natural gas sector.

Natural Gas-Related Transportation

California's transportation sector is vital to the state's economy; the freight transportation system is responsible for one-third of the state's economic product and jobs.⁶⁴ However, transportation is also responsible for the majority of the state's environmental concerns. The transportation sector accounts directly for 39 percent of GHG emissions and 80 percent of NO_x emissions. Heavy-duty trucks are the largest contributors to NO_x emissions and continue to impact air quality heavily in the state's severely polluted air basins. To address these concerns, extensive near-term deployment of low-emission technologies is necessary to meet current and future clean air standards. It is paramount to develop and deploy commercially viable technologies that meet the state's sustainability goals while increasing freight transportation efficiency and competitiveness.

When used as an alternative transportation fuel to diesel, natural gas can reduce petroleum dependency, greenhouse gas emissions, local air pollution, and operating costs for businesses and consumers. Because of the characteristics of natural gas fuel, natural gas vehicles face unique market barriers. The *2015 Natural Gas Vehicle Research Roadmap*⁶⁵ identifies these barriers, which include but are not limited to, vehicle and engine performance and availability, emissions and environmental performance, storage and infrastructure limitations, and data analysis and information sharing.

The Energy Commission funds natural gas-related transportation research to address these market barriers and continuously advance the science in natural gas vehicle technology to reduce emissions beyond applicable standards. Previous work includes developing near-zero NO_x engines, which subsequently led to the successful commercialization of several engines certified at CARB's optional low-NO_x standards. The Energy Commission has funded research

⁶⁴ *California Sustainable Freight Action Plan*. July 2016.

http://www.casustainablefreight.org/documents/PlanElements/Main%20Document_FINAL_07272016.pdf.

⁶⁵ *2015 Natural Gas Vehicle Research Roadmap*. Schroeder, Alex. October 2016.

<http://www.energy.ca.gov/2015publications/CEC-500-2015-091/CEC-500-2015-091-CMF.pdf>.

on a variety of technologies to increase efficiency of natural gas vehicles, including high-energy ignition, hybridization, and advanced and innovative engine concepts. Research on improving fast-fill compressed natural gas fueling infrastructure continues with the goal of maximizing vehicle range and on-board storage use. The Energy Commission has also funded research on natural gas off-road vehicles to expand the air quality benefits of natural gas to another highly polluting mobile sector. Future research proposed this year includes engine development to fill gaps in availability and engine research to meet long-term efficiency and emissions goals.

The Energy Commission's transportation research area contains a vast portfolio of projects that continuously builds on knowledge gained from previous efforts. For example, hybridization was initially sought for efficiency benefits, but emission tradeoffs were less understood. As a result, research focusing on systems optimization was pursued to better understand the benefits of holistic hybrid design with a shared focus on efficiency and emission improvements. The continuous advancement of natural gas vehicles is a promising approach to help address California's clean transportation goals.

The proposed budget for Natural Gas-Related Transportation is \$4 million (Table 7).

Table 7: FY 2018-19 Proposed Natural Gas Research Budget Plan Summary – Natural Gas Related – Transportation

Program Area – Natural Gas Related-Transportation	Proposed Budget
Proposed Research Initiatives: <ul style="list-style-type: none"> ▪ Develop High Efficiency, Low Emission, Production-Ready Heavy-Duty Natural Gas Engines for Long Haul Applications ▪ Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel 	\$4,000,000

Source: California Energy Commission

Natural Gas-Related Transportation Program Goals

The goals of transportation-related research projects in selected sectors are to:

- Accelerate the beneficial commercial adoption of near-zero emission gas vehicles to improve air quality.
- Improve the energy efficiency and performance of gas vehicles to reduce carbon emissions and compete with conventional fuel vehicles.
- Increase the use of renewable gas to reduce the GHG emissions of the transportation sector.
- Improve fueling infrastructure technology capabilities to promote the further adoption of gas vehicles.

Proposed Research Initiatives: Natural Gas-Related Transportation

Project 1: Develop High Efficiency, Low Emission, Production-Ready Heavy-Duty Natural Gas Engines for Long Haul Applications

The Issue

SB 1383 identifies short-lived climate pollutant (SLCP) reduction targets, including a 40 percent reduction of methane by 2030.⁶⁶ *The 2017 Integrated Energy Policy Report (IEPR)* identifies renewable natural gas use in medium- and heavy-duty vehicles as an important and cost-effective strategy for improving air quality and reducing methane emissions.⁶⁷ The further growth of natural gas vehicles (NGVs) is a critical economic downstream driver for collecting and distributing California's available biomethane resources. When combining the benefits of renewable natural gas with ultra-low nitrogen oxide (NO_x) engines, NGVs represent a sustainable long-term solution to achieving both greenhouse gas and criteria pollutant emission reductions. Replacing diesel trucks with low NO_x NGVs can improve air quality in California's high-volume freight corridors and the surrounding disadvantaged communities.

The largest newly certified and commercially available on-road natural gas engine in the North American market is the Cummins Westport ISX12N. However, the 12-liter engine is available only up to 400 horsepower (hp) with a peak torque of 1450 lb-ft, potentially limiting the applications of the engines. In the past, engine development for 15-liter natural gas engines was placed on hold due to the uncertainty of long-haul market acceptance at the time.⁶⁸ The *2015 Natural Gas Vehicle Research Roadmap* identifies the gap in availability for engines larger than 12-liters because of these paused efforts.⁶⁹

Natural gas fueling infrastructure continues to expand steadily with a 50 percent national increase in the number of compressed natural gas (CNG) stations between 2012 and 2016.⁷⁰ The release of the near-zero-NO_x 12-liter engine is expected to further catalyze infrastructure development and market maturity. In addition, the *2017 IEPR Transportation Energy Demand Forecast* projects more than 300 percent growth in natural gas truck stock by 2030.⁷¹ With the expectation of NGV market growth in parallel with the growing availability of renewable natural

66 California Air Resources Board. March 2017. *Short-Lived Climate Pollutant Reduction Strategy*. https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf.

67 California Energy Commission. October 2017. *Draft 2017 Integrated Energy Policy Report*. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-01/TN221520_20171016T153945_Draft_2017_Integrated_Energy_Policy_Report.pdf.

68 Berg, Tom. Work 'Paused' on Cummins Natural Gas Engine. January 2014. <http://www.truckinginfo.com/channel/fuel-smarts/news/story/2014/01/work-paused-on-isx15-gas-due-to-market-timing-uncertainty-cummins-says.aspx>.

69 Schroeder, Alex. 2015 Natural Gas Vehicle Research Roadmap. October 2016. <http://www.energy.ca.gov/2015publications/CEC-500-2015-091/CEC-500-2015-091-CMF.pdf>.

70 Stations. NGVAmerica.org. Natural Gas Vehicles for America. <http://www.ngvamerica.org/stations/>.

71 California Energy Commission. Transportation Energy Demand Forecast, 2018-2030. December 2017. http://docketpublic.energy.ca.gov/PublicDocuments/17-IEPR-05/TN221893_20171204T085928_Transportation_Energy_Demand_Forecast_20182030.pdf.

gas, larger natural gas engines must be developed to encourage adoption of the fuel by the long haul trucking market.

The Research

This research integrates applicable high TRL technologies with heavy-duty on-road natural gas engines to fill the gap in availability for engines larger than 12 liters. The research will build on previous transportation research on engine efficiency improvements to develop production-ready prototype engines that exhibit high-efficiency, near-zero emissions, and manufacturability. Projects will coordinate technology providers with engine manufacturers to ensure a robust supply chain for the delivery of commercial products. As with previous Energy Commission-funded engine development projects, there is potential for the Alternative and Renewable Fuels and Vehicle Technology Program (ARFVTP) and other programs to collaboratively fund vehicle demonstration and deployment of engines developed through this research.

The Benefits

- **Energy Sector.** As of 2016, the total natural gas demand for California's transportation sector is roughly 170 million gasoline gallon equivalents (GGEs) annually. In a mid-case scenario, the 2017 IEPR estimates a steady increase of natural gas demand for transportation to 200 million GGEs by 2020 and 340 million GGEs by 2030 with significant adoption of the fuel for heavy-duty trucks.⁷² Large-scale adoption in the long-haul trucking sector can further displace diesel fuel consumption and encourage the use of domestic renewable natural gas.
- **Technology Potential.** This research focuses on the integration of high-TRL engine efficiency and low-emission technologies with natural gas engines suitable for long-haul trucks. This research is critical to bridging innovative technology providers with engine original equipment manufacturers (OEMs) to deliver production-ready engines.
- **Market Connection.** Although this initiative targets mainly the long haul trucking market other vehicle applications that require additional power and torque may also be targeted by this initiative. Engine development programs typically require around three years of engine prototyping, optimization, and vehicle demonstration to produce a commercial product.
- **Energy and Cost Savings.** The long-haul sector places high value on efficiency and the reduction of operating costs. This research focuses on adopting high TRL engine efficiency technologies that will result in lower GHG emissions and fuel cost savings.
- **Environmental Benefits.** California will benefit from expanded NGV adoption and replacement of diesel long haul trucks due to lower criteria pollutants and reduced greenhouse gas emissions. Targeting the high-fuel-consuming long-haul sector can provide substantial demand for renewable natural gas production and the capture of California's biomethane resources.

⁷² Ibid.

Project 2: Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel

The Issue

Fuel efficiency deficits of 10 to 20 percent (depending on application and duty cycle) compared to diesel continue to limit the economic and environmental benefits of natural gas as a transportation fuel. A recent study by Argonne National Laboratory evaluated the well-to-wheels environmental implications of natural gas as a transportation fuel. The study identified vehicle fuel efficiency along with methane leakage rates in the natural gas supply chain as the major drivers to the relative GHG emission performance of NGVs.⁷³ Efficiency losses from spark-ignited stoichiometric natural gas engines stem from throttling, compression ratio limitations, and difficulties with dilute combustion.

Designing an internal combustion engine that combines the attributes of Otto and Diesel engines has long been an engineering goal for engine manufacturers. Recent developments such as Mazda's plan to release a spark-controlled compression ignition gasoline engine in 2019 indicate increasing technology maturity. The technology has the potential to deliver up to 30 percent higher fuel efficiency, diesel-like low-speed torque, and ultra-low emissions.⁷⁴ Natural gas engines share similar characteristics to gasoline engines therefore, they have the potential to demonstrate similar benefits through the use of compression ignition.

The *2015 Natural Gas Vehicle Research Roadmap* identifies natural gas compression ignition engine research as a long-term goal for achieving future performance and emission targets.⁷⁵ Previous Natural Gas R&D Program efforts have concentrated on efficiency improvements in spark-ignited natural gas engines based on a need for near-term commercialization. Near-term and long-term solutions must be considered to ensure continued advancement of natural gas engine technology.

Additional research is required to test innovative engine designs and verify the benefits of natural gas compression ignition to lay the foundation for the potential commercialization in the NGV market.

The Research

This initiative proposes research to demonstrate the viability of natural gas compression ignition engines. Projects will focus on engine-level R&D with some potential for validation through vehicle demonstration. The research will need to address issues related to natural gas compression ignition such as engine knock, misfires, fuel quality sensitivity, operating range, and controllability.

73 Cai, H., Burnham, A., Chen, R., Wang, M. Wells to wheels: Environmental implications of natural gas as a transportation fuel. *Energy Policy* 109, 565-578. 2017. <http://dx.doi.org/10.1016/j.enpol.2017.07.041>

74 Skyactiv-X Next-Generation Gasoline Engine. October 2017. <https://insidemazda.mazdausa.com/press-release/mazda-next-generation-technology-press-information/>

75 Ibid.

Potential projects include, but are not limited to:

- Testing high-pressure direct injection using a non-diesel pilot fuel such as dimethyl ether to achieve diesel-like efficiency and performance while minimizing particulate matter and NO_x emissions.
- Researching homogenous charge compression ignition for natural gas engines. Focus on controls development and extending the range of compression ignition operation.
- Demonstrating the benefits of reactivity controlled compression ignition using natural gas in combination with a high-cetane pilot fuel.

Projects will aim to achieve performance and efficiency comparable to diesel in addition to low NO_x and particulate matter emissions comparable to spark-ignited natural gas engines. Due to the high thermal efficiency potential of this approach, advanced after treatment technologies may be needed with the capability to perform under lower exhaust temperatures. Projects must be cognizant of potential paths to commercialization and reduce dependency on system complexity or high cost components where possible.

The Benefits

- **Energy Sector.** This research will support continued progress in efficiency improvements for natural gas engines. Closing the gap between NGVs and diesel vehicles will provide energy security and air quality benefits to California's transportation sector by reducing reliance on petroleum fuels.
- **Technology Potential.** This research focuses on advancing low to mid TRL technologies with a long-term goal of using in commercial heavy-duty natural gas engines.
- **Market Connection.** This initiative targets primarily the heavy-duty natural gas truck market. The time to market is expected to parallel similar work done with gasoline compression ignition engines. Depending on project results and manufacturer acceptance, the technology may reach commercialization in five years.
- **Energy and Cost Savings.** Operating costs and capital payback times will be reduced with increased engine efficiency. Research must lead to cost-effective opportunities to support commercialization.
- **Environmental Benefits.** Increased engine efficiency directly results in GHG emission reductions due to lower fuel consumption. Compression ignition technologies have the potential to deliver efficiency benefits of up to 30 percent.⁷⁶ This initiative will address challenges in maintaining low criteria pollutant emissions (specifically NO_x) while achieving diesel-like performance in a natural gas compression ignition engine.

⁷⁶ Ibid.

GLOSSARY

CARB	California Air Resources Board
BTU	British thermal unit
CHP	combined heat and power
CNG	compressed natural gas
CO ₂	carbon dioxide
CPUC	California Public Utilities Commission
DG	distributed generation
GGEs	gasoline gallon equivalents
GHG	greenhouse gas
HVAC	heating, ventilation, and air-conditioning
IEPR	<i>Integrated Energy Policy Report</i>
IOUs	investor-owned utilities
MW	megawatts
NAAQS	National Ambient Air Quality Standards
NO _x	nitrogen oxides
NGV	natural gas vehicle
ORNL	Oak Ridge National Laboratory
PG&E	Pacific Gas and Electric Co.
PHMSA	Pipeline and Hazardous Materials Safety Administration
PRCI	Pipeline Research Council International
R&D	Energy Commission's Research and Development Division
SCADA	Supervisory Control and Data Acquisition
SoCal Gas	Southern California Gas Company
WHP	waste heat to power
ZNE	zero -net energy

**APPENDIX A:
PRESENTATION FROM JANUARY 25, 2018
STAFF WORKSHOP TO DISCUSS
PROPOSED FY 2018-19 NATURAL GAS
RESEARCH INITIATIVES**

Refer to: <http://www.energy.ca.gov/research/notices/#01252018>

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP ON PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

Refer to: <http://www.energy.ca.gov/research/notices/#01252018>



FY 2018-19 Natural Gas Research Initiatives AND Proposed Natural Gas Research Program Expansion Request

Presented at the Stakeholders Workshop
California Energy Commission
January 25, 2018
9:00 am – 5:00 pm

*Post-workshop edits in **GREEN**



Morning Agenda

Time	Topic
9:00 am	Introduction and Purpose – Laurie ten Hope <ul style="list-style-type: none">▪ Commitment to Diversity▪ Proposed Natural Gas FY 2018-19 Budget
9:30 am	Staff Presentations on Proposed Natural Gas Research Initiatives: <ul style="list-style-type: none">▪ Energy Efficiency – Colin Corby▪ Renewable Energy and Advanced Generation – Kevin Uy▪ Natural Gas Infrastructure Safety and Integrity – David Erne▪ Energy-Related Environmental Research – Yu Hou▪ Natural Gas-Related Transportation – Peter Chen
11:00 am – Noon	Public Comments
Noon – 12:15 pm	Next Steps and Break for Lunch – Laurie ten Hope



Afternoon Agenda*

Time	Topic
1:15 pm	Introduction and Purpose – Laurie ten Hope <ul style="list-style-type: none">▪ Proposed Natural Gas Research Program Expansion Request▪ Background and Motivation▪ Proposed Key Program Features
1:30 pm	Presentation on Proposed Natural Gas Research Initiatives – Kevin Uy <ul style="list-style-type: none">▪ Program Impacts▪ Proposed Key Research Areas▪ Expanded Program Scope, Timing, and Funding
2:15 pm – 3:30 pm	Public Comments
3:30 pm – 4:00 pm	Closing & Next Steps – Laurie ten Hope

**Afternoon session may begin before lunch if morning session ends early.*



Introduction

- For the Natural Gas FY 2017-18 budget, the Energy Commission R&D Program included a public vetting process with Stakeholders that included a public workshop.
- For the upcoming Natural Gas FY 2018-19 budget, Energy Commission R&D Program staff are holding this workshop seeking stakeholder comments on natural gas research initiatives.
- For the upcoming proposed Natural Gas R&D Program Expansion Plan request, staff also seek stakeholder feedback on proposed program changes.
- Specific “Questions for Stakeholders” will be posed during the workshop.



General Approach

- Identify research gaps for research initiatives through:
 - Discussion with utilities, public stakeholders, state and federal governmental agencies, other Energy Commission programs, and
 - Roadmaps
 - Public meetings with industry and trade associations
 - Research ideas submitted by the public
- Research projects are selected through competitive solicitations
- Energy research priorities are guided by policy directives
- Need clearly identified benefits



Commitment to Diversity

The Energy Commission adopted a formal resolution strengthening its commitment to diversity in our funding programs. We continue to encourage disadvantaged and underrepresented businesses and communities to engage in and benefit from our many programs.

To meet this commitment, Energy Commission staff conducts outreach efforts and activities to:

- Engage with disadvantaged and underrepresented groups throughout the state.
- Notify potential new applicants about the Energy Commission's funding opportunities.
- Assist applicants in understanding how to apply for funding from the Energy Commission's programs.
- Survey participants to chart progress in diversity outreach efforts.



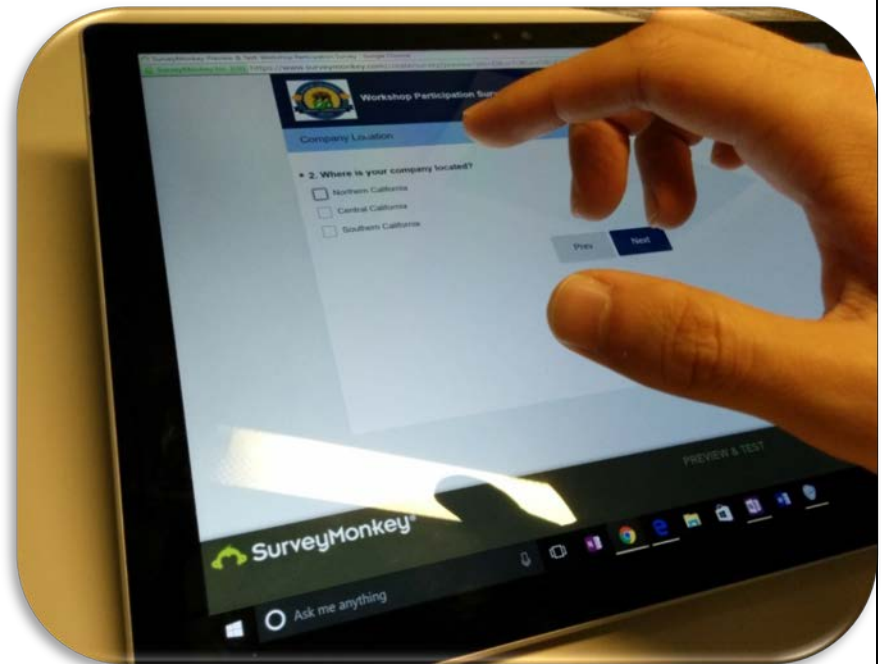
We Want to Hear From You!

1 Minute Survey

- ❖ The information supplied will be used for public reporting purposes to display anonymous overall attendance of diverse groups.
- Does your company identify as an underrepresented group?
- Where is your company located?
- How did you hear about the workshop?

Online survey for WebEx Participants:

<https://www.surveymonkey.com/r/CEC-01-25-2018>





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CALIFORNIA ENERGY COMMISSION

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Find Partners Through LinkedIn



The Energy Commission has created a user-driven LinkedIn Networking group page to help potential applicants connect, collaborate, and partner on proposals for research funding opportunities. Participants may subscribe to the *"California Energy Commission Networking Hub"* by clicking on this link:

bit.ly/CalEnergyNetwork



Policy Drivers

<i>FY 2018-19 Natural Gas Proposed Budget Plan</i>	<i>Research Areas</i>				
<i>Policy Drivers</i>	<i>Efficiency *</i>	<i>Renew- ables **</i>	<i>Safety and Integrity ***</i>	<i>Environ- mental ****</i>	<i>Trans- portation *****</i>
Energy Action Plan: Establishes goals to ensure adequate, reliable, and reasonably-priced natural gas supplies are achieved through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers.	X	X	X	X	X
Integrated Energy Policy Report: Biennial Report to Governor and Legislature on trends and issues concerning electricity and natural gas, transportation, energy efficiency, renewables, and public interest energy research	X	X	X	X	X
Assembly Bill 32: Global Warming Solutions Act. Requires GHG emission reduction of 15% below 1990 levels by 2020 for transition to a sustainable, low-carbon future while maintaining a robust economy.	X	X	X	X	X
Senate Bill 32: Requires California to reduce GHG emissions to 40% below 1990 levels by 2030.	X	X	X	X	X
California's 2017 Climate Change Scoping Plan. Establishes framework of action for California to meet 40 percent reduction in greenhouse gases by 2030 compared to 1990 levels. Builds off of programs established by AB 32.	X	X	X	X	X
Senate Bill 1250: Public Goods Utilities surcharge to support public interest R&D for energy efficiency and renewable, conservation activities.	X	X	X	X	X
Public Resources Code 25620: Directs state to undertake public interest energy RD&D projects that are not adequately provided by energy markets and to advance energy science or technologies of value to California ratepayers.	X	X	X	X	X
Public Utilities Code Section 895: Provides statutory authority for the Energy Commission to administer the natural gas funds.	X	X	X	X	X
Executive Order B-30-15: Set greenhouse gas reduction target of 40 percent below 1990 levels by 2030.	X	X		X	X
Senate Bill 350: Clean Energy and Pollution Reduction Act of 2015. Establishes annual targets to achieve 50% renewables and cumulative doubling of statewide energy efficiency savings by Jan. 1, 2030.	X	X			
Energy Efficiency Buildings Standards (Title 24, Part 6). Standards for energy and water efficiency requirements to reduce California's energy consumption.	X				

(*Energy Efficiency Research, **Renewable Energy and Advanced Generation, ***Infrastructure Safety and Integrity, ****Energy-Related Environmental Research, *****Natural Gas-Related Transportation Research)



Policy Drivers (cont.)

<i>FY 2018-19 Natural Gas Proposed Budget Plan</i>	<i>Research Areas</i>				
<i>Policy Drivers</i>	<i>Efficiency *</i>	<i>Renew- ables **</i>	<i>Safety and Integrity ***</i>	<i>Environ- mental ****</i>	<i>Trans- portation *****</i>
Appliance Energy Efficiency Standards (Title 20, Division 2, Chapter 4, Article 4, Sections 1601-1608 Appliance Efficiency Regulations): Standards to reduce energy consumption and improve energy efficiency of residential and commercial appliances.	X				
Assembly Bill 758: Achieves greater energy savings in existing residential and nonresidential buildings.	X				
Assembly Bill 531: Discloses commercial building electric and natural gas use.	X				
California Energy Efficiency Strategic Plan: Zero Net Energy Buildings, transformation of HVAC industry, increase of NG use in on-site renewable energy and agricultural sectors.	X				
Senate Bill X1-2 - Renewables Portfolio Standard: Sets goals for 30 percent of retail sales from renewable energy resources by end of 2020.		X			
Assembly Bill 1613 - Waste Heat and Carbon Emissions Reduction Act: Requires electrical corporations to purchase excess electricity from CHP systems that comply with sizing, energy efficiency, and air pollution control requirements.		X			
Governor Brown's Clean Energy Jobs Plan: California to develop 12,000 MW of localized energy by 2020, make new buildings in California ZNE, and incentives for increased use of cogeneration by 6,500 MW by 2030.	X	X			
Bioenergy Action Plan: Sets goals for the production and use of electricity and fuels made from biomass.		X			
SB1383: Short-Lived Climate Pollutant Reduction Strategy. Recommends actions to reduce emissions of short-lived climate pollutants (SLCPs), including those from dairies, organics disposal, and WWTPs.		X		X	X
High Energy Efficiency, Low Emissions Combustion, and Control Technology Development Program: Addresses goal to improve environmental quality while meeting the wide-ranging demand for energy.	X	X		X	

(*Energy Efficiency Research, **Renewable Energy and Advanced Generation, ***Infrastructure Safety and Integrity, ****Energy-Related Environmental Research, *****Natural Gas-Related Transportation Research)



Policy Drivers (cont.)

FY 2018-19 Natural Gas Proposed Budget Plan		Research Areas				
Policy Drivers		Efficiency *	Renew- ables **	Safety and Integrity ***	Environ- mental ****	Trans- portation *****
Executive Order B-29-15: Established actions to save water, prevent wasteful water use, streamline state's drought response, and invest in new technologies to make California more drought-resilient.				X	X	
SB 1371 - Natural Gas Leakage Abatement: To determine if existing practices are effective at reducing methane leaks, if alternative practices may be more effective with consideration to safety, reliability and affordability.				X		
CPUC Natural Gas Safety Action Plan: Ensures Californians receive safe, reliable utility service and infrastructure through safety compliance and enforcement, risk management/assessment, improved safety policy and safety promotion.				X		
Senate Bill 887: Natural Gas Storage Wells. Requires operators to notify the CPUC immediately of a leak of any size from gas storage well. Requires CPUC to notify public about reported leak that cannot be controlled within 48 hours.				X		
Governor's Aliso Canyon Gas Leak Proclamation: Directs further action to protect public health and safety, ensure accountability and strengthen oversight of gas storage facilities.				X		
Senate Bill 380: Order to determine feasibility of minimizing or eliminating use of the Aliso Canyon NG storage facility while still maintaining energy and electric reliability for the region.				X		
Executive Order B-32-15: Sustainable Freight Action Plan. Establishes the following: improve freight system efficiency by 25% by 2030, deploy 100k freight vehicles capable of zero-emission operation and maximize near-zero freight vehicles powered by renewables by 2030.						X
2016 Mobile Source Strategy: Reduce emissions GHGs and other pollutants from the heavy-duty vehicle sector with cleaner combustion engines, renewable fuels, and zero-emission technology to meet GHG reduction targets and attain federal health-based air quality standards for ozone and particulate matter.						X
Low Carbon Fuels Standard (LCFS): Reduce the full fuel-cycle, carbon intensity of transportation fuel pool in California through transition to cleaner/less-polluting fuels with a lower carbon footprint.						X
AB 118 and AB 8: Alternative and Renewable Fuels and Vehicle Technology Program. Increase deployment of vehicles and infrastructure for use of alternative fuels in transportation sector.						X

(*Energy Efficiency Research, **Renewable Energy and Advanced Generation, ***Infrastructure Safety and Integrity, ****Energy-Related Environmental Research, *****Natural Gas-Related Transportation Research)



Budget and Priorities

- Transparent Budget Process
- Clean Energy Transformation Priorities
 - Infrastructure Safety
 - Climate Preparedness
 - System Decarbonization through Efficiency, Renewables and Lower Intensity Transportation
 - Equity
 - Ratepayer Benefits and California Focus
- Support State Energy Policies and Governor's priorities
- Issues of Elevated Importance in 2017 Continue in 2018
 - Governor's Executive Orders B-29-15 and B-30-15 on climate and drought
 - Greenhouse Gas Emission Reduction (AB 32 and SB 32)
 - CPUC Natural Gas Safety Policy Statement (July 2014)
 - Natural Gas: Leakage Abatement (SB 1371)
 - Governor's Aliso Canyon Gas Leak Proclamation
 - California Air Resources Board's (CARB) *Climate Change Scoping Plan Update*:
 - 1)** Ensure safety of natural gas system **2)** decrease fugitive methane emissions; and **3)** reduce dependence on fossil fuel natural gas



Research Areas and Proposed Natural Gas FY 2018-19 Budget

Research Areas	Proposed Budget
Energy Efficiency	\$6,000,000
Renewable Energy and Advanced Generation	\$3,000,000
Energy Infrastructure	\$8,600,000
<i>Natural Gas Infrastructure Safety and Integrity (5.6M)</i>	
<i>Energy-Related Environmental Research (3M)</i>	
Natural Gas-Related Transportation	\$4,000,000
Program Administration	\$2,400,000
TOTAL	\$24,000,000



Workshop Format

- Each Natural Gas R&D team will discuss their presentation
- Questions related to the research initiatives will be posed to the Stakeholders at the end of each research area
- There will be an additional public comment period at the conclusion of the presentations
- To ensure each team has time to complete their presentations, some questions may need to be deferred to the public comment period



Role of Stakeholders

- Advice and comments on the initiatives
- Alerting Energy Commission staff to possible duplication of efforts
- Advising Energy Commission staff on opportunities to gain synergies in research efforts, including partnering on funding to increase scale of research
- Facilitating the effective transfer and use of research results
- Identify missing initiatives



Industrial End Use Energy Efficiency



Presenter: Colin Corby



Goals

Conduct R&D to help the industrial sector:

- Increase energy efficiency
- Reduce operating costs
- Increase the industry's competitiveness in the global economy while reducing greenhouse gas emissions
- Develop measures to meet environmental challenges while maintaining or enhancing energy efficiency including:
 - Reduce water or other finite resource consumption
 - Maintain or increase productivity while reducing emissions (e.g., low NOx)
- Commercialize technologies with broad market penetration



Current Portfolio

Increase Efficiency and Reduce GHG Emissions from Natural Gas Using Facilities

Develop and demonstrate emerging energy saving technologies that can directly reduce natural gas use and greenhouse gases and other emissions.

Pending projects:

- Demonstrate low temperature, heat recovery for the chemical industry using low cost sulfur as a phase change material and eliminating costly pressure vessels and compressors.
- Demonstrate smart combustion technology using natural gas fuel quality sensors to predict fuel quality and adjust burners to optimize combustion.
- Demonstrate high efficiency, low emission natural gas fired combustion system for industrial and commercial processing that can constantly monitor multiple burner zones to optimize performance.
- Develop a technical assessment report to identify research needed to help the chemical and allied products industry reduce natural gas use.

Staff have recommended the above projects which will be considered at a future Energy Commission Business Meeting.



Current Portfolio

Industrial Natural Gas Energy Efficiency

Demonstrate pre-commercial and/or emerging energy efficient technologies that reduce natural gas use.

Examples of active projects:

- Demonstrate infrared heating technology to reduce natural gas use for drying nuts, fruits and vegetables.
- Test burner designs that can efficiently burn both natural gas and biofuels.
- Demonstrate an advanced rotary drum dryer coupled with a heat pump to reduce natural gas used for drying of bulk foods.
- Demonstrate an advanced low NOx combustion systems for industrial bakeries that reduces process temperature, NOx emissions while increasing energy efficiency.



Program Highlights

Conversion of Low Value Waste Heat into High Value Energy Savings

- **Recipient:** Gallo Cattle Company
- **R&D Funds:** \$1,207,136 (Match \$402,379)
- **Goal:** Use low value waste heat for industrial chilling, boiler, cleaning and water pre-heating with the goal of reduce site natural gas use by 23% and electricity use by 38%
- **Technology:** Develop and demonstrate a multi-stage heat recovery system that can take waste heat from biogas generators and economizers to run a ammonia-based absorption chiller.
- **Accomplishments and Market Potential:**
 - System has been designed and installed at Gallo's cheese production facility and currently undergoing testing. Preliminary results show monthly savings of 5,891 therms and 94,748 kWh.
 - Successful demonstration could pave the way for others to use this technology to recover waste heat for chilling and hot water needs and thus, reduce energy and costs.
- **Next Steps:**
 - Complete 12 months of measurement and verification.
 - Optimize system to meet 100% of the plant chilling needs, currently at 40%.





Program Highlights

Integration of Advanced Solar Thermal Technology Into Industrial Processes

- **Recipient:** ergSol
- **R&D Funds:** \$ 1,200,000 (Match: \$300,000)
- **Goal:** Design and demonstrate technical and economic feasibility of a commercial scale integrated solar thermal system capable of producing hot water to supplement hot water produced by steam boilers at a pharmaceutical facility. The goal is to overcome barriers with integrating high efficient solar thermal systems in industrial processing.
- **Technology:** Evacuated Tube Solar Thermal System
- **Accomplishments and Market Potential:**
 - Preliminary design completed for the Roche Laboratory facility in Pleasanton
 - The project will fill important data gaps regarding the performance, savings, economics and design requirements for solar thermal systems that would be directly applicable to other industrial plants.
- **Next Steps:**
 - Measurement and Verification Plan in development
 - Once permits have been approved, construction can begin—estimated March 2018





FY 2018-19 Proposed Funding Initiative

Reduce Natural Gas Use for GHG Emission Intensive Industries

Background:

- California industries account for approximately 36% of total natural gas use (2016) and also annually generate approximately 23% of the greenhouse gas emissions making them a prime target for innovative technologies to reduce natural gas and greenhouse gas emissions.
- SB 350 requires a cumulative doubling of statewide energy efficiency savings in electricity and natural gas final end uses of retail customers by January 1, 2030.
- CPUC resolution G-3519 emphasized the use of R&D funds to target industries and facilities that are emissions intensive and covered under the California Air Resources Board's Cap-and-Trade program.
- Past grants did not attract large natural gas users. A program focused on larger projects could yield substantial natural gas and greenhouse gas savings.



FY 2018-19 Proposed Funding Initiative

Reduce Natural Gas Use for GHG Emission Intensive Industries (*cont.*)

Research Description:

This initiative focuses on industrial facilities that emit more than 10,000 metric tons of greenhouse gas emissions annually. Research focuses on developing and demonstrating technologies that could reduce natural gas and GHG emissions cost effectively while assisting these industries to remain competitive in the global market. Potential research could include the following or integration of multiple approaches:

- Test of advanced non thermal water removal technologies
- Test alternatives to steam for sterilization and process applications
- Test or demonstrate highly efficient combustion systems and fuel flexible industrial combustion systems
- Develop innovative, cost effective systems to recover waste heat
- Develop advanced sensors, controls and models that reduce energy intensity
- Develop and test advanced materials and catalysis for high temperature and harsh environmental conditions
- Assess and deploy best available emission reduction technologies that also result in reductions in natural gas use and greenhouse gas emissions
- Demonstrate advanced solar thermal technologies for enhanced oil recovery

Industries targeted: Food processing, glass, cement, chemical manufacturing, oil and gas extraction and refineries, pharmaceutical, and metal melting and processing.

Potential Partners and Customers: Industry, utilities, major equipment manufacturers, public/private research organizations and governmental agencies.

Estimated Ratepayer Benefits: Reduce energy use and costs, reduce greenhouse gas and other air emissions, potential to assist industries to be economically competitive in California.



Proposed FY 2018-19 Budget

Initiatives	Proposed FY 2018-19 Natural Gas Budget
Industrial, Agriculture and Water Efficiency <ul style="list-style-type: none">▪ Reduce Natural Gas Use for GHG Emission Intensive Industries	\$6,000,000



Questions for the Stakeholders on Industrial, Agriculture and Water Efficiency

- We want projects that have significant natural gas savings while reducing greenhouse gas emissions. However, projects with highest potential savings often have a higher risk of not being successful in the first application. Are large industrial users more interested in incremental improvements or transformative technologies?
- Given the current low price of natural gas and need to reduce greenhouse gas emissions, what specific energy efficiency research gaps and technologies should be targeted to help California industries be competitive?
- What recommendations do you have to more effectively bring *large* natural gas industrial users into this program:
 - How best to reach industrial customers?
 - How to encourage researchers, industry groups, or industrial customers to apply for research funding?
 - How best to expand the adoption of demonstrated technologies beyond the 1st pilot?
 - Would fewer, yet larger awards (e.g. \$3-6 million) increase program participation?
- Besides grants, what other strategies would be effective in de-risking technology adoption?



Renewable Energy and Advanced Generation



Presenter: Kevin Uy



Goals

With funding under the EPIC and the Natural Gas R&D programs, the Renewable Energy and Advanced Generation program area conducts research that reduces barriers and increases penetration of renewable energy.

Under the natural gas research program, our goal is to reduce dependence on fossil-derived natural gas by:

- Advancing the development and market availability of clean and efficient distributed generation (DG) and combined heat and power (CHP) technologies
- Developing hybrid, fuel-flexible, energy efficient, and low emission DG technologies for natural gas and alternative fuels including biogas
- Developing and demonstrating technologies for the conversion, cleanup, and upgrading of biogas to renewable natural gas



Current Portfolio

Advancing Clean Energy through Biogas, Biomethane, and Natural Gas

- Innovative technologies and strategies for converting biomass resources to biogas and for cleaning and upgrading biogas to renewable natural gas.

Novel Solutions to Accelerate Deployment of Small and Micro-Scale Combined Cooling Heating and Power (CCHP) Systems

- Enabling technologies including thermal energy storage and thermally-driven cooling to expand the applicability of CCHP systems.

Improving Waste Heat to Power and Near-Zero Emission DG Systems

- Innovative technologies for converting industrial waste heat to electricity, and DG systems which can achieve near-zero criteria pollutant emissions (focus on NO_x) while maintaining high efficiency.

Piloting Pipeline Quality Renewable Natural Gas from California's Forest Biomass Resources

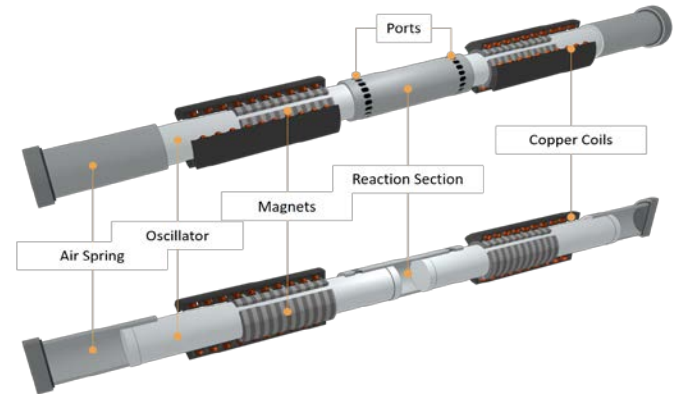
- New technologies which can cost-effectively convert California's abundant forest waste biomass into pipeline-quality renewable natural gas.



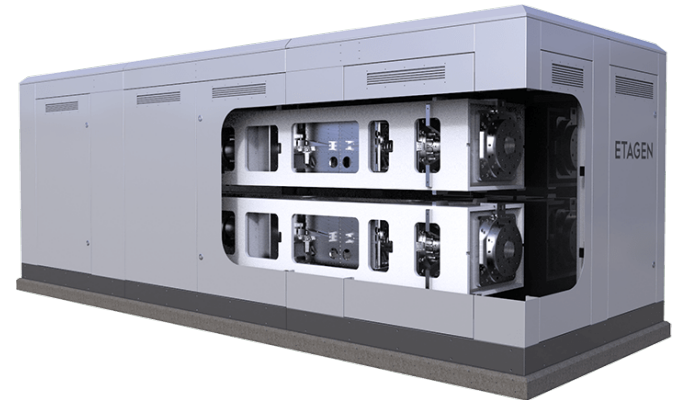
Program Highlights

High Compression Ratio Free Piston Engine for CHP

- **Recipient:** EtaGen
- **R&D Funds:** \$796,247 (Match \$1,099,580)
- **Goal:** Design, build, and field test a high compression ratio, low-emission, free-piston generator for CHP applications.
- **Technology**
 - Linear, opposed, free-piston engine architecture
 - Utilizes low-temperature homogenous charge compression ignition (HCCI) combustion
 - Air springs and linear generators allow for oil-free and linkage-free operation
- **Accomplishments and Market Potential:**
 - Demonstrated 75 kW within a packaged system
 - Demonstrated very high efficiency, 40% electrical, 80% thermal
 - Able to exceed CARB DG emission standards
 - Variable compression ratio allows for fuel-flexible operation



Cross-section illustration of EtaGen's free-piston linear generator



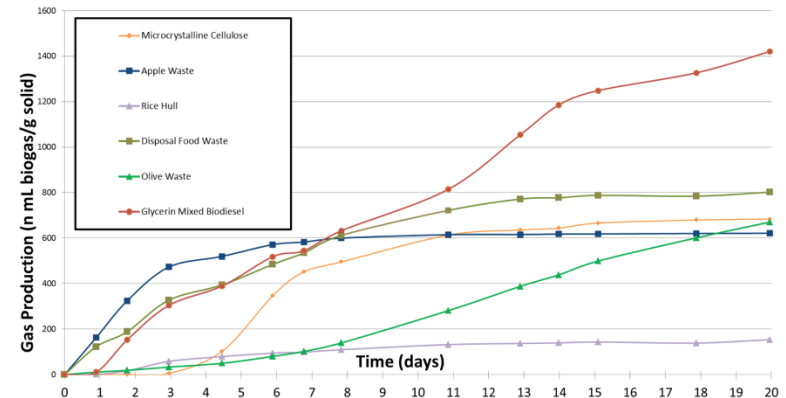
Cutaway rendering of upcoming 250 kW packaged system



Program Highlights

Optimization of Biogas Production

- **Recipient:** Biogas Energy
- **R&D Funds:** \$415,000 (Match \$112,100)
- **Goal:** Study the operation of the anaerobic digestion process to improve biogas production
- **Technology:**
 - Experiments conducted at three scales
 - 160 mL lab-scale assays
 - 100 gallon pilot-scale digester
 - 100 ton per day commercial-scale digester
- **Accomplishments:**
 - Quantified biomethane potential for over 25 digester feedstocks, including biogas composition and volume over time.
 - Identified key digester parameters to maintain optimal biogas production and avoid crash events.
 - Produced a best practices manual for anaerobic digester operation.



Biogas production over time for some of the feedstocks tested



Photo of the commercial-scale host, North State Rendering



Program Highlights

Renewable Natural Gas from Woody Biomass

- **Recipient:** University of California, San Diego
- **R&D Funds:** \$1,000,000 (Match \$237,000)
- **Goal:** Develop cost-effective means for converting woody biomass to renewable natural gas
- **Technology:**
 - Fast-internally circulating fluidized bed (FICFB) gasifier which converts woody biomass into producer gas with high efficiency (>70%).
 - Biodiesel scrubber to clean tars and other contaminants from producer gas.
 - Bench-scale fluidized-bed methanation reactor converts cleaned producer gas to RNG.
- **Accomplishments:**
 - Systems met performance goals
 - FICFB and biodiesel scrubber produced a clean, high BTU producer gas, and the methanation reactor converted producer gas to RNG.
 - Techno-economic analysis of a full-scale facility is being performed for the final report.



Photo of the fast internally circulating fluidized bed gasifier at the Woodland Biomass Research Center



FY 2018-19 Proposed Funding Initiatives

Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities

Background:

- Heavy wind gusts, particularly in high fire risk regions, and severe weather events impact power generation and distribution and, in many cases, resulted in wide scale power interruptions that impacted critical facilities.
- Furthermore, large amounts of intermittent renewables such as solar PVs will be added to California's electricity mix by 2030. This is expected to result in large diurnal swings in electric load.
- To mitigate the impacts of these events and to reduce natural gas use from utility scale power generation , there is need to improve the functionality and readiness to deploy advanced distributed generators.
- Both grid system operators and microgrid operators have expressed a need for biogas-distributed generation (DG) systems which can operate flexibly, similar to large-scale peaker plants, in order to balance intermittent load at the distribution-scale.
- These advanced biogas DG systems could serve as a critical distributed energy resource for local load management.



FY 2018-19 Proposed Funding Initiatives

Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities *(cont.)*

Research Description:

- Research will support pre-commercial technologies and strategies which addresses the technical and economic barriers related to deploying clean and efficient distributed generation, including CHP and CCHP systems, as a key power enabler in high fire risk regions, to support critical facilities, and as a key component of an integrated modern energy system.
- Possible technologies and strategies include, but are not limited to, the following:
 - Clean and efficient distributed generation, including biogas-fueled systems, which are capable of fast ramping and maintain high efficiency over a large operating range.
 - Advanced DG and CHP systems built with improved functionality to support integration with renewable energy, energy storage, and microgrid controllers, particularly in critical facilities.
 - Advanced DG, including biogas fueled DG and CHP system control methodology which enable increased renewable generation while improving reliability in high fire risk areas and critical facilities.
- Technologies should focus on the advantages of the baseline technology over baseline, conventional DG systems.
- Analysis will be conducted on biogas-DG versus electric grid storage on effectiveness to mitigate intermittency.



FY 2018-19 Proposed Funding Initiatives

Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities *(cont.)*

Potential Partners and Customers:

Critical facilities (e.g. hospitals); educational, residential, commercial and light industrial facilities; other facilities and communities with advanced energy systems; technology manufacturers and providers, project developers, fleet owners and operators, utilities, and local, state and federal agencies

Estimated Ratepayer Benefits:

- Reduce statewide consumption of NG while providing increased reliability, flexibility, and power quality, reduced transmission and distribution losses, and reduced transmission congestion on the local electric grid.
- Allow facility owners to affordably meet their on-site electric and thermal needs.
- Provide energy and cost savings as a result of increased deployment of small-CHP (e.g. BEW Engineering and LLNL report estimated \$105 million in cost savings from 448 MW of small-CHP)



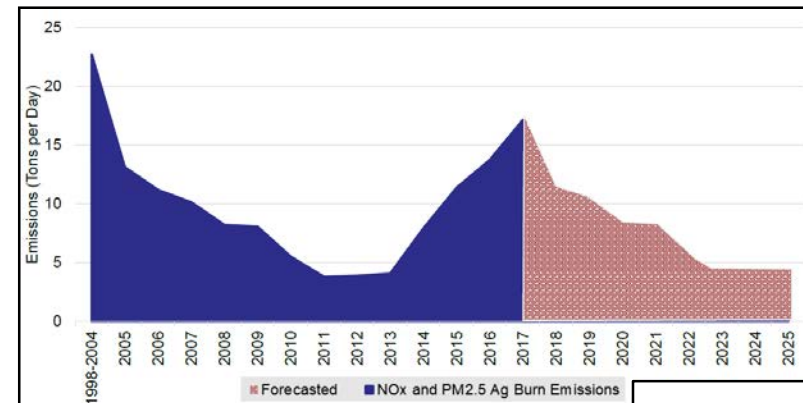
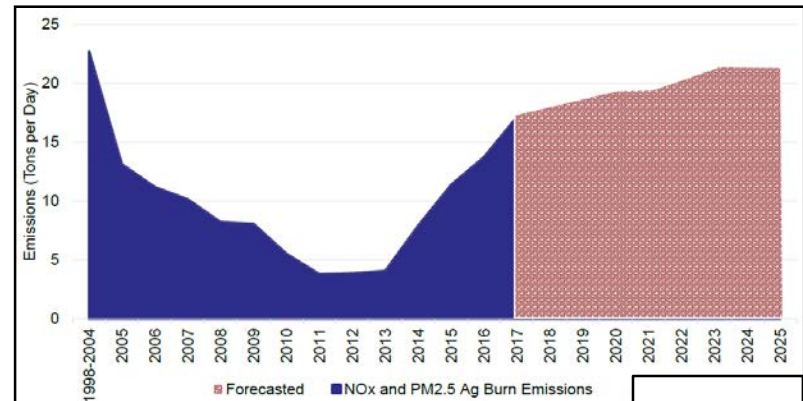
FY 2018-19 Proposed Funding Initiatives

Central Valley Agricultural Waste Resources to Energy

Background:

- Recent legislation (SB 1383) calls for dramatic reductions in short-lived climate pollutant emissions (SLCPs) by 2030, including a 40% reduction for methane.
- Central Valley farms produce large amounts of residues (i.e. orchard and agronomic crop wastes) which could be viable resources for renewable energy generation.
 - Disposal through open pile burning contributes significant particulate emissions to an already pollution burdened region with many disadvantaged communities and projections show an upward trend. Recent SJVAPCD summit focused on the urgent need to find cost-effective alternatives to open pile burning, including bioenergy.
- There is significant potential to capture and convert farm residues into bioenergy, thereby reducing dependence of fossil natural gas. However, ability to handle these feedstock and economically convert to energy remain a major challenge.

Open Burning Emissions Without (top chart) and With (bottom chart) Cost Effective Alternative



Source: J. Olsen, 2017. Central Valley Summit on Alternatives to Open Burning of Ag Waste.



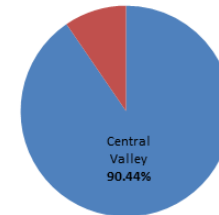
FY 2018-19 Proposed Funding Initiatives

Central Valley Agricultural Waste Resources to Energy (cont.)

Background:

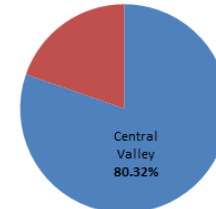
- Central Valley farms also produce enormous quantity of livestock manure, a single largest source of methane emissions in California (approximately 25%)
 - The primary method for capture and conversion of manure to energy is via anaerobic digestion (AD) (demonstrated at several large California dairy farms). Current AD systems are scale-dependent and not economical at small livestock farms in California.
- Converting these livestock manure to energy in a cost-effective way that will also benefit smaller farms, and be used for various applications (e.g. process heating for dairies, supplemental onsite electricity or further upgrading for transportation use) will reduce dependence on fossil natural gas.
- Research initiative is part of overall biogas/biomethane route to decarbonization and supports low income and disadvantaged communities (as called for in CPUC Proposed Decision G-3527)

Number of Dairy Cows



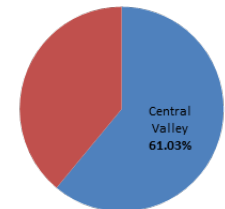
State Total: 1,738,090
CV Total: 1,571,923

Number of Dairies



State Total: 1,392
CV Total: 1,118

Dairies in Counties with an Average of <1000 Cows



State Total: 585
CV Total: 357

Source: CDFA's Dairy Statistics Annual 2016.

- About Small (less than 1000 cows) Dairy Farms in California:
 - Half of all dairy farms in CA (USDA 2012 census data)
 - Only 3 out of 16 dairy digester projects in CA (EPA AgStar)
 - 20% of all dairy cows, with 70 MW potential, and 4% of statewide methane emissions (staff estimate)
- Recent large grant funding, e.g. \$35 million to 18 dairies (CDFA-DDRDP) and \$11 million to 3 dairies (EPIC), went to large dairies (21% of methane emissions); CDFA has another \$99 million for dairies.
- Proposed NG fund (\$2 million) relative to methane emissions is proportionately high and targets disadvantaged dairy sectors in the Central Valley.



FY 2018-19 Proposed Funding Initiatives

Central Valley Agricultural Waste Resources to Energy *(cont.)*

Research Description:

- Research will support pre-commercial technologies and strategies to enable effective and economic conversion of agricultural residues to energy systems (as an alternative to open pile burning) in the California Central Valley.
- Possible technologies and strategies include, but are not limited to, the following:
 - Pre-process steps that improve handling and conversion of agricultural biomass coupled with conversion technology;
 - Pre-engineered systems capable of low-cost deployment at farms in the Central Valley;
 - Innovative strategies such as aggregation of waste from several small farms to a central bioenergy plant to improve cost-effectiveness;
 - Thermochemical route of biomethane production from farm residues; and
 - Improvements to thermochemical systems to allow for economical, small-scale operation.
- Projects must demonstrate a “whole system approach” from feedstock to end use – conversion of organic waste to renewable energy (heat, electricity, and/or renewable natural gas for transportation use).
- Technologies should focus on maximizing energy and air quality benefits in addition to economic benefits.



FY 2018-19 Proposed Funding Initiatives

Central Valley Agricultural Waste Resources to Energy *(cont.)*

Potential Partners and Customers:

Farm owners and operators, technology manufacturers and providers, project developers, fleet owners and operators, utilities, and local, state and federal agencies

Estimated Ratepayer Benefits:

- Increase energy security and offset fossil fuel use by utilizing biogas for renewable heat, electricity, and/or vehicle fuel.
- Reduce emissions of methane, which accounts for 9% of annual GHG emissions in California.
- Conserve natural gas by utilizing in-state biomass resources.



Proposed FY 2018-19 Budget

Initiatives	Proposed FY 2018-19 Natural Gas Budget
Renewable Energy and Advanced Generation <ul style="list-style-type: none">▪ Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities▪ Central Valley Agricultural Waste Resources to Energy	\$3,000,000

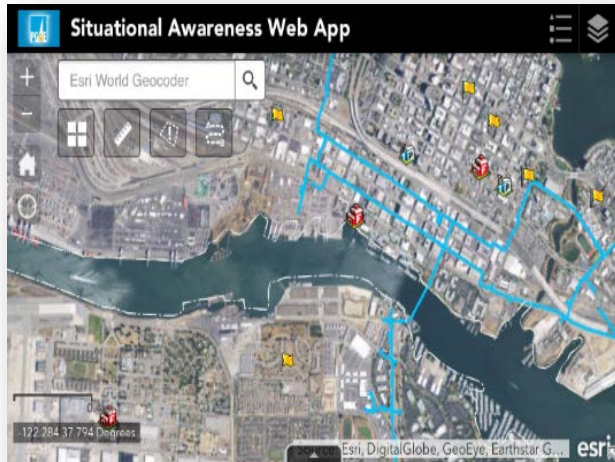


Questions for the Stakeholders on Renewable Energy and Advanced Generation Research Initiatives

- Are there other bioconversion technologies or pathways we should consider funding?
- What technologies would make the largest impact on improving air quality in the Central Valley?
- What are the non-technology barriers to deploying bioenergy systems at small farms (i.e. lack of available on-site expertise, financing, etc.)? How could we address these barriers?
- What advanced functionality for biogas fueled-DG systems would be most desired by facility owners?
- What advanced functionality would be most desired by grid operators?
- In what applications are biogas fueled-D G systems preferred over electricity and energy storage and vice versa?
- What applications benefit the most from the two integrated together?



Natural Gas Infrastructure Safety & Integrity



Presenter: David Erne



Goals

- Conduct research in natural gas infrastructure – pipelines and storage – to increase public safety and system integrity and enhance transmission and distribution capabilities of the natural gas system; and
- Address issues not adequately addressed by the regulatory and competitive markets



Current Portfolio

Assessing System Vulnerabilities

- High Accuracy Mapping for Pipeline Excavation Damage Prevention and Emergency Response
- Multi-analytic Risk Management Tool for Pipeline Risk
- Barrier-based Quantitative Risk Management Approach for Underground Storage of Natural Gas
- Integrated Risk Management and Decision Support System for Underground Natural Gas Storage Infrastructure Integrity Under Various Failure Scenarios

Preventing Failure

- Rapid+ Pipeline Safety and Integrity Monitoring System
- Pipeline Safety and Integrity Monitoring Technologies Assessment
- Pipeline Right-of-Way Monitoring and Notification System
- GPS Excavation Encroachment Notification System

New Areas Under Development

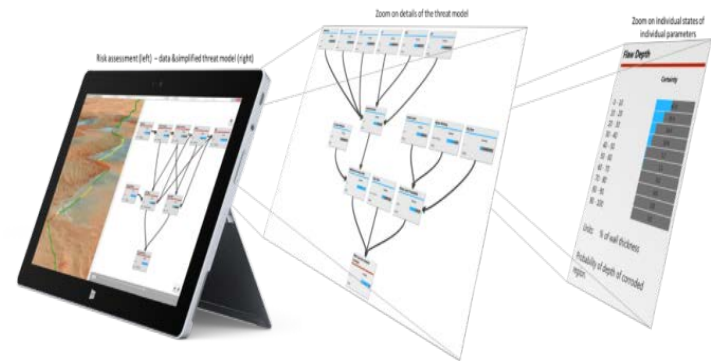
- Seismic Risk Assessment
- Improved Inspector Training



Program Highlights

Multi-analytic Risk Management Tool for Pipelines

- **Recipient:** DNV-GL
- **R&D Funds:** \$1,309,305 (Match \$411,761)
- **Goal:** Demonstrate an advanced risk assessment methodology to identify leading indicators of risk to pipelines (e.g., corrosion, external threats)
- **Methodology:**
 - Apply Bayesian network models for pipeline corrosion and external damage
- **Accomplishments:**
 - Created a network threat model for pipeline external corrosion
 - Demonstrated the use of the methodology to SoCalGas and PG&E to predict pipeline risks
 - Developed a methodology to help pipeline operators make operational decisions with little or no data
- **Next Steps**
 - Helping pipeline operators use the risk assessment methodology in their current workflow



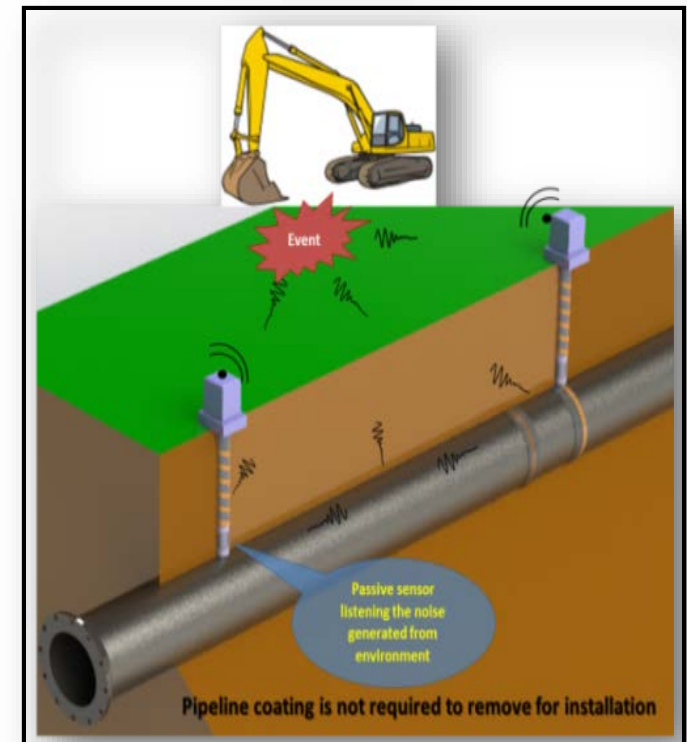
Software allows the user to see how a threat evolves in time and by location (left). Also, the mechanism that will lead to pipeline failure is shown and no assumptions are hidden from the user (right).



Program Highlights

Enhancing the Real-time Active Pipeline Integrity Detection (RAPID) System

- **Recipient:** Acellent Technologies
- **R&D Funds:** \$1,633,093 (Match \$103,000)
- **Goal:** Expand RAPID capabilities to detect encroachment
- **Technology:**
 - Acoustic sensor system
- **Accomplishments and Market Potential:**
 - Determined design requirements based on the collaboration with utilities and gas pipeline industries
 - Tested the integrated RAPID+ sensor system in the laboratory environment
 - Integrated the multi-state acoustic and vibration sensors for encroachment detection.
 - Obtained utility acceptance of test requirements and installation plan of the encroachment detection system
- **Next Steps**
 - Working with utilities to select testing sites for testing in 2018





Program Highlights

GPS Excavation Encroachment Notification System

- **Recipient:** GTI
- **R&D Funds:** \$1,301,288 (Match \$170,000)
- **Goal:** Develop and demonstrate a excavator-mounted encroachment notification device
- **Technology:**
 - GPS-based alert system
- **Accomplishments and Market Potential:**
 - Completed development of the encroachment system
 - Deployed and demonstrated the technology in the PG&E and SoCal Gas service areas, including building and installing 150 devices on operating excavators and backhoes
- **Next Steps**
 - Install additional devices at the request of the IOUs
 - Prepare final report





FY 2018-19 Proposed Funding Initiatives

Developing Sensors for Pipeline and Storage Damage Prevention

Background:

- Pipeline and storage infrastructure has a significant diversity in structure and systems (e.g., materials of construction, age, connection types, manufacturers)
- Challenging to manage the infrastructure and predict risks without a better inventory of relevant component data and site characteristics

Research Description:

- Demonstrate low-cost, advanced sensors to allow IOUs to greatly expand the ability to gather field data (e.g., materials of construction, certifications, horizontal and vertical location, pressure), and more effectively predict potential failures

Potential Partners and Customers:

- Utilities

Estimated Ratepayer Benefits:

- Supports the ability to more effectively and efficiently identify and address risks to the infrastructure and reduce accidents.



FY 2018-19 Proposed Funding Initiatives

Modeling Mechanical Failure

Background:

- Current risk modeling approaches consider a small subset of factors that can cause failures in the infrastructure
- Multi-factor analysis is necessary to better identify system risks

Research Description:

- Develop predictive tools that account for a greater number of possible threats to evaluate the probability of failure of the network, determine the highest threat of failure, develop the most appropriate mitigation strategies, and take optimal preventive maintenance and replacement actions

Potential Partners and Customers:

- Utilities

Estimated Ratepayer Benefits:

- Supports the ability to more effectively and efficiently identify and address risks to the infrastructure



FY 2018-19 Proposed Funding Initiatives

Improving Automated Shutoff Equipment for Natural Gas Infrastructure

Background:

- Natural catastrophes or human activity can damage gas infrastructure, leading to a catastrophic release
- Automatic shutoff devices, such as excess flow valves could provide a substantial safeguard to major releases

Research Description:

- Develop, test, and demonstrate automatic shutoff technologies to limit the consequences from breaks or ruptures caused by impacts, high pressures, or other causes. Possible projects include development of shutoff valves, regulator equipment, monitoring and automated control of shutoff valves, or other innovative technologies.

Potential Partners and Customers:

- Utilities

Estimated Ratepayer Benefits:

- Provides rapid response capabilities to substantially reduce natural gas releases



Proposed FY 2018-19 Budget

Initiatives	Proposed FY 2018-19 Natural Gas Budget
Natural Gas Infrastructure Safety and Integrity <ul style="list-style-type: none">▪ Developing Sensors for Pipeline and Storage Damage Prevention▪ Modeling Mechanical Failure▪ Improving Automated Shutoff Equipment for Natural Gas Infrastructure	\$5,600,000



Questions for the Stakeholders on Natural Gas Infrastructure Safety & Integrity

- Are we addressing the most critical safety and integrity needs?
- How can we leverage technologies from other industries to improve the natural gas infrastructure?
- How can we grow the research community?



Energy-Related Environmental Research



Presenter: Yu Hou



Goals

- Develop cost-effective approaches to evaluating and resolving environmental effects of natural gas production, delivery, and use in California;
- Explore how new energy applications and products can solve/mitigate environmental problems; and
- Identify vulnerabilities of the energy system to climate change and develop cost-effective approaches to ensure reliable natural gas services.



Current Portfolio

Advancing characterization of methane emissions from California's natural gas system

- The Commission pioneered the methane emission research in the State
- Current and past projects cover all sectors of the California natural gas system
- Multi-tiered detection system deployed to identify emission sources

Climate change vulnerability and adaption research

- Working with IOUs to identify vulnerabilities and adaption options
- Conduct natural gas energy scenarios analysis

Air quality and public Health impacts

- Indoor air quality and ventilation solutions
- Air quality and public health implications from biogas/biomethane



Program Highlights

Air Quality Impacts of Using Biogas in California

- **Recipient:** University of California, Davis
- **R&D Funds:** \$775,064
- **Goal:** To measure biogas/biomethane chemical and biological composition, evaluate the potential air quality impacts of using biogas/biomethane
- **Methodology:**
 - Biogas sources: landfills, food waste digesters, and dairy waste digesters.
 - Applications: power generation, home appliances, and mobile platform.
 - Exhaust sample collected, aged, and analyzed.
- **Results and Next Steps:**
 - Preliminary results show that exhaust from biomethane has a similar commonly known chemical composition as that from pipeline natural gas. However, additional research is required to determine whether any health impacts may be introduced by unknown trace chemical compounds from the biomethane exhaust.

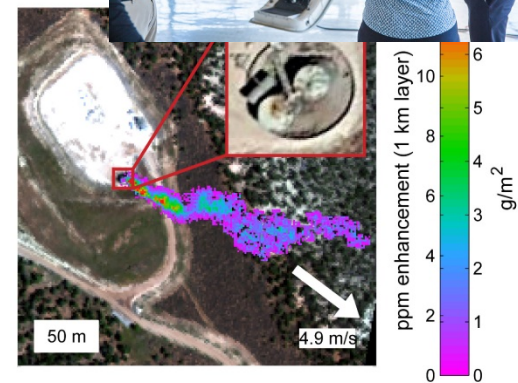
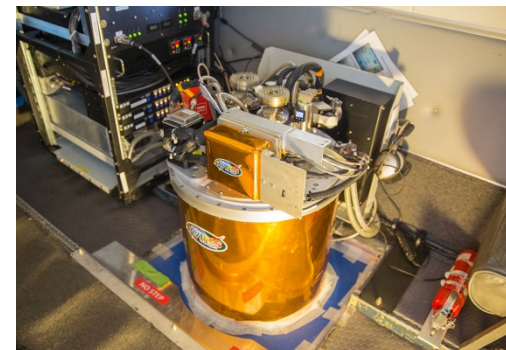




Program Highlights

Identification of Large Fugitive Methane Emitters from the Natural Gas Sector

- **Recipient:** National Aeronautics and Space Administration/Jet Propulsion Laboratory (NASA/JPL)
- **R&D Funds:** \$600,000 (Match: \$700,000, CARB)
- **Goal:** Obtain data on large methane fugitive emissions sources by surveying a fraction of California's natural gas infrastructure. Deploying NASA's Airborne Visible InfraRed Imaging Spectrometer – Next Generation (AVIRIS-NG) in California to identify large fugitive methane emitters from the natural gas sector.
- **Technology and Methodology:**
 - Deploying airborne visible infrared imaging spectrometer over key regions that are major contributors to California's methane budget. Energy Commission funds natural gas and CARB funds all sectors.
 - Measurement data is processed into maps of large source emitters.
- **Results and Next Steps:**
 - Airborne survey covered total of 32,000 km². Total of 229,000 potential sources (CARB, NASA and Energy Commission funds).
 - Data analysis is ongoing and expecting final results in summer.





FY 2018-19 Proposed Funding Initiatives

Fostering Natural Gas Sector Resilience

Background:

- Recognizing the imperative of systematically preparing California's energy system to be resilient in the face of climate change, the 2017 Draft IEPR includes the recommendation to "explore establishing a California Partnership for Energy Sector Climate Resilience."
- As articulated by SoCalGas, "...for climate plans to be effective, every region of California must be considered and engaged. Specifically, SoCalGas wants to be involved in establishing a California Partnership for Energy Sector Climate Resilience and convening a joint-agency workshop on climate resilience metrics to help track California's action and successes."
- The draft 2017 IEPR also recommended consideration of climate resilience metrics to help track California's resilience action and successes.
- The State of California has made available extensive projections of future climate that are relevant to natural gas sector planning, operations, and management. However, energy sector resilience is a young and rapidly evolving field, and little is known regarding best practices for designing and implementing natural gas resilience strategies.
- At Energy Commission workshops in 2017, IOUs indicated the need to collaborate closely on design of research projects to ensure that research is actionable.



FY 2018-19 Proposed Funding Initiatives

Fostering Natural Gas Sector Resilience (*cont.*)

Research Description:

- The proposed research effort would, ideally, be a test-case of involving IOUs in designing a research project that would directly support natural gas sector resilience in California via the California Partnership.
- The successful research team would work closely with California natural gas IOUs and build on, or address gaps identified by RAMP filings.
- Based on guidance from the CPUC/CEC/OPR/CalOES Adaptation Working Group and input from IOUs, specific research goals might include:
 - Development of metrics to assess and track progress in natural gas system resilience;
 - Identification of which scenarios, including but not limited to extreme events, are most important for stress-testing the natural gas system, with attention to infrastructure as well as operational considerations and interconnectedness with other critical systems;
 - Development of methods for integrating resilience investments into cost-benefit analyses; and
 - Conducting potential case studies to pilot test the methodologies.

Potential Partners and Customers: Natural gas utilities, CPUC, OPR, CNRA, and local governments.

Estimated Ratepayer Benefits: Cost-effectively preserving reliability, safety, and efficient operations in the face of a changing climate requires that IOUs have scientifically sound methodologies to develop and implement resilience strategies as well as track resilience.



FY 2018-19 Proposed Funding Initiatives

Measuring the GHG and Air Pollutant Emissions from RNG Project

Background:

- Installing RNG projects in landfills, dairies, and waste water treatment plants can reduce GHG emissions and criteria air pollutants. Some of the projects are located in disadvantaged and low income communities.
- Reductions in odor complaints have been reported when some RNG projects were implemented.
- Current GHG inventory methods have deficiencies for multiple reasons, including estimating emissions based on a relatively small number of measurements.
- Preliminary results from field measurements on methane, including the NASA/JPL study, suggest that actual emissions can be much higher than estimated emissions.
- There is also a need to conduct additional research on potential public health implications from combusting upgraded biomethane compared to those from combusting natural gas.



FY 2018-19 Proposed Funding Initiatives

Measuring the GHG and Air Pollutant Emissions from RNG Project (*cont.*)

Research Description:

- This research will use field measurements to quantify GHG and criteria air pollutant emissions before and after RNG projects are implemented.
- Repeated measurements are needed to estimate annual emissions from the facilities.
- The main objective is to measure overall emissions and compare them with estimates generated using regulatory methods to better quantify the benefits from RNG projects.
- Conduct post-combustion emission measurements and analysis for upgraded biomethane to determine public health impacts compared to natural gas combustion.
- Builds on current UCD project
- Will develop best practices to reduce GHG

Potential Partners and Customers:

- CARB, CDFA, RNG project developers, local air districts and other local community organizations.

Estimated Ratepayer Benefits:

- Assist in the quantification of actual emissions associated with RNG projects.
- Ensure air quality in local communities near the RNG project developments.



Proposed FY 2018-19 Budget

Initiatives	Proposed FY 2018-19 Natural Gas Budget
Energy-Related Environmental Research <ul style="list-style-type: none">▪ Fostering Natural Gas Sector Resilience▪ Measuring the GHG Emissions Benefits of Renewable Natural Gas	\$3,000,000

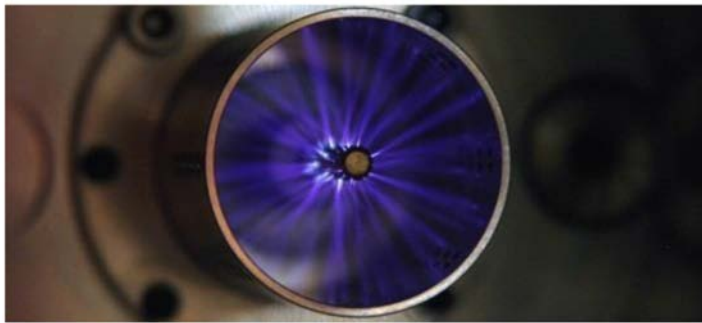


Questions for the Stakeholders on Energy-Related Environmental Research

- Are there additional or alternative ways than those identified in the “Fostering Natural Gas Sector Resilience” initiative that the Energy Commission could assist utilities on natural gas vulnerability research?
- Which emissions from RNG projects, in addition to GHGs, should be included in the study in the “Measuring the GHG Benefits of Renewable Natural Gas” initiative?
- In these initiatives, is the Energy Commission addressing the most important environmental issues that would affect the natural gas system in the next 5 to 10 years?



Natural Gas-Related Transportation Research



Presenter: Peter Chen



Goals

The goals of transportation-related projects are to:

- Increase freight efficiency and competitiveness
- Reduce carbon emissions and increase the use of renewable transportation fuels
- Improve air quality
- Improve infrastructure capacity, reliability, and sustainability



Current Portfolio

Near-Zero Emission Natural Gas Engine Development

- Commercialized three heavy-duty natural gas engines certified to CARB's optional low NOx standards.

Natural Gas Fueling Infrastructure Improvements

- Improving fast-fill CNG dispenser technology to improve storage tank utilization and vehicle range.

In-Use Emissions and Fuel Usage Study

- Conducting real-world tests to characterize actual natural gas vehicle emissions and fuel usage.

Natural Gas Hybrid-Electric Vehicles

- Improving fuel efficiency and air quality benefits of natural gas vehicles by optimizing the integration of advanced hybrid drivetrains.

Advanced Combustion Research

- Developing advanced ignition systems that can extend the dilution tolerance of natural gas engines.
- Applying innovative engine efficiency improvement technologies to close efficiency deficit while maintaining near-zero emissions.

Natural Gas in Off-Road Applications








- Adapting low emission on-road natural gas engine technology to off-road vehicles.



Program Highlights

Natural Gas 12-Liter Engine to Deliver Near-Zero Option for Regional Haul

- **Recipient:** South Coast Air Quality Management District
- **R&D Funds:** \$1.0M
- **Goal:** Develop and commercialize a near-zero emission 12-liter natural gas engine.
- **Technology and Accomplishments:**
 - Enhanced after-treatment, controls, and fuel system to achieve near-zero NOx emissions.
 - CARB certified at 0.02 g/bhp-hr NOx. Engine release in February 2018.
 - Over 880,000 demonstration miles clocked with participation from key manufacturers and fleets.
- **Market Potential:** San Pedro Bay Ports Clean Air Action Plan aims to have 13-20% of the drayage truck fleet operating in the ports to be near-zero emission by 2021– opportunity for other major Ports.
- **Benefits:** Improve air quality in California’s densest freight corridors by reducing NOx emissions by 90%. Improve GHG benefits of natural gas vehicles by reducing methane emissions by 70%.

TRUCK							COACH	
OEM	Freightliner	Peterbilt	Kenworth	Volvo	Mack	Autocar	OEM	MCI
								
Model	Cascadia Day Cab, Sleepers 114SD	320 384 365 579 567	W900S T660 T800 SH T680 T880	VNL	Pinnacle	Xpeditor	Model	Commuter Coach
Application	Tractor	Refuse Tractor Vocational	Tractor Vocational	Tractor	Tractor	Refuse	Application	Motorcoach



Program Highlights

CNG Hybrid Power System for Off-Road Vehicles

- **Recipient:** Terzo Power Systems, LLC.
- **R&D Funds:** \$1.5M
- **Goal:** Develop and integrate a CNG hybrid-electric power system to power an off-road almond harvester.
- **Technology and Accomplishments:**
 - De-couple engine from hydraulics and propulsion with a series hybrid architecture to increase efficiency.
 - Hybrid technology recognized in the 2017 Sacramento Region Innovation Awards for Sustainability.
 - Field demonstration will take place in Madera almond orchard over the 2018 harvest season.
- **Market Potential:**
 - Almonds are California's #1 agricultural export with production spanning the San Joaquin Valley.
 - Modular and scalable design has potential to expand adoption to other off-road agricultural applications.
- **Benefits:**
 - Improve air quality for agricultural communities.
 - Introduce a cleaner, more energy efficient alternative for off-road agricultural vehicles.





FY 2018-19 Proposed Funding Initiatives

Develop High Efficiency, Low Emission, Production-Ready Natural Gas Engines for Long Haul Applications

Background:

- California's transportation natural gas demand is currently at around 21 percent of the total RNG production potential from in-state waste resources. For this reason, the further growth of the NGV market is critical to taking full advantage of California's available resources for RNG production.
- Adoption of medium- and heavy-duty natural gas vehicles equipped with near-zero emission engines and running on RNG is a cost effective strategy for improving air quality and reducing GHG and SLCP emissions.
- The 2015 Natural Gas Vehicle Research Roadmap identifies previous efforts to develop larger engines that were placed on hold, leaving a gap in availability for engines larger than 12-liters.
- The NGV market continues to steadily mature: CNG fueling infrastructure availability has increased by 50 percent between 2012 and 2016; the 2017 IEPR projects an over 300 percent growth in natural gas truck stock by 2030 (mid-case).



FY 2018-19 Proposed Funding Initiatives

Develop High Efficiency, Low Emission, Production-Ready Natural Gas Engines for Long Haul Applications (*cont.*)

Research Description:

- Integrate mature technologies with heavy-duty on-road natural gas engines. Focus on larger engines to fill remaining gap in availability.
- Build on previous transportation research on advanced combustion, engine efficiency, and emission reduction. Aim for developing a production-ready engine.
- Projects should coordinate technology providers with engine manufacturers to ensure a robust supply chain for the delivery of commercial products.

Potential Partners: Partners may include research institutions, national labs, technology manufacturers and providers, other governmental agencies, and private industry manufacturers.

Estimated Ratepayer Benefits:

- Build economic case for the production of RNG by developing engine for long haul trucking markets. In-state RNG production increases energy security and reduces dependency on fossil fuels.
- Reduce NOx and particulate matter emissions by displacing high polluting trucks.



FY 2018-19 Proposed Funding Initiatives

Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel

Background:

- Previous Natural Gas R&D Program efforts have concentrated on efficiency improvements in spark-ignited natural gas engines with a focus on near-term commercialization.
- The 2015 Natural Gas Vehicle Research Roadmap identifies natural gas compression ignition engine research as a long-term goal for achieving future performance and emission targets.
- Significant advancements have been made with gasoline compression ignition engines, with claims of efficiency improvements of up to 30 percent.
- There is potential to apply these advancements to heavy-duty natural gas engines. Additional research is needed to verify benefits and lay the foundation for potential commercialization.



FY 2018-19 Proposed Funding Initiatives

Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel (*cont.*)

Research Description:

- Conduct R&D on the development of advanced combustion engine concepts; demonstrate the viability of natural gas compression ignition engine designs.
- Aim to demonstrate diesel-like efficiency and torque performance while maintaining the low emission benefits of natural gas engines.
- Focus on topics such as precise controls development, knock prevention, and fuel variance considerations.

Potential Partners: Partners may include research institutions, national labs, technology manufacturers and providers, other governmental agencies, and private industry manufacturers.

Ratepayer Benefits:

- Increased natural gas engine performance while maintaining low emissions.
- Reduced operating costs and payback times for NGVs by increasing engine efficiency.



Proposed FY 2018-19 Budget

Initiatives	Proposed FY 2018-19 Natural Gas Budget
Natural Gas-Related Transportation <ul style="list-style-type: none">▪ Develop High Efficiency, Low Emission, Production-Ready Natural Gas Engines for Long Haul Applications▪ Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel	\$4,000,000



Questions for the Stakeholders on Natural Gas-Related Transportation

- Are we prioritizing the right initiatives to advance the science of natural gas-related transportation technologies?
- What other research is needed to increase the economics, performance, and environmental benefits of natural gas vehicles?
- What other research is needed to accelerate the beneficial adoption of on-road natural gas vehicles?
- How can we best address technology barriers to expanding natural gas use in off-road applications?

General Questions:

- Are there opportunities for partnerships to leverage additional funding?
If so, what are the priority areas that require more emphasis?
- Are there opportunities for collaboration or synergies? If so, with whom?



Public Comments and Questions

- ❖ Please state your name and affiliation
- ❖ Please limit your comments to 3 minutes to allow time for others



Closing Comments

- ❖ Submit additional written questions/comments related to the FY 2018-19 Natural Gas R&D Budget Plan to:

Tiffany Solorio

tiffany.solorio@energy.ca.gov

Deadline to submit written questions/comments:

Thursday, February 1, 2018 - 5:00 PM PDT

- ❖ Final draft to be submitted to the California Public Utilities Commission by March 31, 2018
- ❖ Copies of presentations and public comments from today's workshop will be posted at: <http://www.energy.ca.gov/research/notices/#01252018>
- ❖ Copies of past budget documents can be found at:
http://www.energy.ca.gov/research/annual_reports.html

**APPENDIX B: QUESTIONS AND ANSWERS FROM
JANUARY 25, 2018 STAFF WORKSHOP
TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS
RESEARCH INITIATIVES**

The following is a summary of stakeholder questions and comments submitted orally and in writing, including Energy Commission staff responses.

Industrial Agriculture & Water Efficiency:

Julia Levin: Bioenergy Association of California

Workshop Comment #1:

Strongly support this program area. You don't mention converting agricultural livestock waste to energy as one of the research areas. It seems like there's such an incredible opportunity to reduce short lived climate pollutants from burning of agricultural waste and from livestock methane. It seems like a really important omission that should be corrected. That's a critical funding area to figure out how to convert agricultural and livestock waste to renewable gas that can help replace fossil fuels gas. We really encourage you to add that specifically in this section.

Energy Commission Response:

Thank you for your comment. Converting agricultural waste to energy is addressed in the Renewable Energy and Advanced Generation R&D initiatives.

Bud Bebe – California Hydrogen Business Council

Workshop Comment #2:

Clarification if you could, the largest industrial users of natural gas in California are refineries. But, they have a number of other pathways in R&D available to them. How would do you define large industrial users within this particular budget and program? And, if Ms. ten Hope could elaborate more on the split between EPIC and how hydrogen actually could fit within these. Hydrogen has natural applications and natural commercial interests, both in electricity and natural gas, and our application is between the two and not specifically funded. How do you treat refineries relative to this program? And, secondly, how do you view EPIC and this natural gas program, relative to the Hydrogen technology interests?

Energy Commission Response:

For the purposes of the natural gas R&D initiatives for energy efficiency, large industrial users are those that must report their CO₂ emissions annually to the California Air Resources Board (CARB). Industries/facilities emitting more than 10,000 metric tons of CO₂ annually are required to report these emissions to CARB. Those that emit more than 25,000 metric tons annually must reduce emissions or purchase allowances in quarterly auctions. The natural gas, energy efficiency R&D focuses on how to help these industries reduce energy use and CO₂ emissions.

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

Additionally, hydrogen is not explicitly in the EPIC nor the natural gas research initiatives. We are seeking input on this area on future research needs in order to determine where it fits best with EPIC or natural gas R&D and how it could be a strategy for decarbonization of the industrial and other sectors.

In regards to refineries, they are eligible to participate in the program with research projects that meet the requirements of the solicitation.

Chris Savage (WebEx)

Workshop Comment #3:

I would suggest that a meeting with Key Industry Trade Associations would be an important outreach activity to encourage participation. Also, larger awards are better than smaller given the increasing cost of technology.

Energy Commission Response:

We acknowledge and thank you for the comment.

Sara Polgar (WebEx):

Workshop Comment #4:

I did not understand how commercial natural gas efficiency projects were being covered. It seems like there's a hole where these types of projects are not available for funding through EPIC funds, but also might not be available here. If novel cost effective solutions can be demonstrated for small businesses such as restaurants to save substantial natural gas, what is the appropriate way to work with the CEC?

Energy Commission Response:

We have several small efficiency commercial projects that we have done in our portfolio in the past, and there is a good representation over the last few years and currently with several active research projects benefit smaller entities such as restaurants. We would also like to mention for commercially available efficiency technology there are utility programs that are available, so that could be another avenue for exploration.

Department of Energy, Lawrence Berkeley National Laboratory (Email #1)

Comment:

Through research on related natural gas appliances for the Department of Energy (DOE) a group of researchers at LBNL has taken note of and interest in examining potential efficiency opportunities with residential room gravity, wall and floor room furnaces.

The appliance, combustion and procurement researchers here at LBNL urge CEC to at a minimum investigate the population and insitu use of these highly inefficient and dangerous heaters. A small study absolutely needs to be done to test the commonly held assumptions that have heretofore prevented research and subsequent standards development around these

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

heaters found in residential (probably in low income) and light commercial structures throughout California.

These assumptions that need to be investigated are:

- There are too few of the room gravity heaters (wall and floor mounted) operating in CA.
- The operating hours of these units is very low and the current energy standards that address the pilot light are sufficient energy policies.
- The existing stock of units operate at rated efficiencies in the upper 70% range.

These gravity heaters are very low cost with retail prices ranging from \$600-\$1,000 depending on Btu/hr and features. Two common brands are Williams Comfort Products and Cozy Heaters Inc.

The research team proposes that the following qualities of these gravity heaters need to be investigated:

1. This class of heating appliances operates in situ at significantly lower than the AFUE rated 69-70% AFUE.
 - a. This appliance draws combustion gas from room and thereby removes heated air.
 - b. Hot combustion gas rising through chimney (or through wall cavity into vented attics) draws air relieved from room - draft diversion.
 - c. The exterior of the heat exchange surfaces collect a large amount of dust and dirt reducing appliances efficiency further.
 - d. The combustion chamber and heat exchange surfaces are made from inexpensive sheet steel that corrodes easily reducing heat transfer.
2. According to the Energy Information Agency (EIA), 2009 Residential Energy Consumption Survey (RECS), there is an estimated 900 K to up 1.7 M of such gravity room heaters in CA. This equates to 14% of residential heating appliances in California.
 - a. Considering the very low efficiency and relatively large population of gravity room furnaces, they have an outsized affect on residential natural gas use. The vast majority of other heating appliances operated at efficiencies greater than 80% AFUE and draw combustion and flue draft air from sources exterior to building.
 - b. This is a significant number of appliances that are not well understood from a performance perspective and therefore lack fundamental data needed to make policy decisions about standards and DSM programs.
3. There is concern that this class of heating appliances may pose serious health and safety risks to residents of California that are as of yet not well understood.

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

- a. During storms or rooms with ventilation fans and or fireplaces, there is concern these changes in air pressure may cause combustion gasses spillage into living spaces.
- b. There are a certain number of appliances vented into the attics (by law only into vented attics).
- c. Though the causes of home fires caused by heating appliances are collected by NFPA, the data is not granular enough to differentiate between types of heating appliances.
 - i. Both floor and wall furnaces have very high surface temperatures which can easily ignite room furnishings (rugs and furniture)

Areas of Possible Research:

1. Establish population, efficiency and emissions data needed for policy makers:
 - a. Improving upon RECS data (as needed) to gain greater insight on population and use of this low efficiency heating appliances in residential and light commercial environments in the CA.
 - b. Establish baseline efficiency and emissions characteristics by testing in combustion lab, using an established test standard (or one modified to cover this class of appliance) using aged samples taken from residences.
 - c. Test and compare aged gravity units against new, out of the box units and those equipped with fans for forced heat circulation.
2. Examine barriers to introducing high efficiency condensing units as a retrofit option to these inefficient room heaters.
 - a. Undertake detailed life cycle analysis of existing and replacement options in both new construction and retrofit applications.
 - b. Work with flue engineers and manufactures to develop a harness product comprised of a coaxial flue, condensate and power line that can be pulled through existing class B flue pipe that these appliances require. This work to be proposed if a analysis shows that it makes financial, sense to pursue a retrofit approach.
 - c. Work with manufacturers (Williams and Cozy for example) to explore the viability of developing a high efficiency appliance that can mount into the cavity of existing unit thereby reducing the cost of replacement.
 - d. Analyze the use of demand side management (DSM) programs as a means of inducing retrofit of this low efficiency product.
 - e. Investigate IAQ and safety issues at greater depth with this subject appliance.
 - f. Provide data and analysis for CA energy policy community to develop appliances standards that address these appliances.
 - g. Propose research through the CEC-EPIC program to investigate the financial and technical feasibility of replacing existing units with ductless split systems as a second option to high efficiency natural gas units.

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

- i. Compare/contract the two options from technical, financial and greenhouse gas characteristics.
- ii. Examine the currently available line-set, condensate and power harnesses for use in retrofit applications – look at how easily this harness can be pulled through existing flue.
- iii. Work with code making committees and manufactures to look at options for condensate disposal.
- iv. Investigate number of residences that have electric service large enough to accommodate ductless split heat pump systems.

Energy Commission Response:

The focus of the natural gas energy efficiency research in the 2018-2019 Proposed Budget Plan is on natural gas and GHG emission intensive industries and facilities-primarily those that emit more than 10,000 metric tons of GHG emissions annually. Some of these industries are subject to the Cap & Trade Program and must reduce emissions or purchase allowances in quarterly auctions.

The CPUC in resolutions G-3519 and G-3527 instructed the Energy Commission to focus on research solutions to help industries covered by the Cap-and-Trade program because they are emissions intensive and trade exposed (EITE) and could potentially relocate outside of California.

With respect to the recommendation regarding research on wall and floor heaters, this was an initiative contained in our 2017-18 natural gas budget plan. We are considering this research topic for a future solicitation (<http://www.energy.ca.gov/contracts/pier.html>). Please be sure to sign up for the Energy Commission's Opportunity List Serve to be notified when it is released.

California League of Food Producers (CLFP) (Email #2)

Comment:

CLFP believes one of the paths to achieve the state's long-range environmental goals is through investments that facilitate research into and foster the development of new and innovative technologies that will enable California's food processing industry to meet compliance challenges through increased efficiency.

CLFP believes that markets/industry factors drive these decisions for most industrial food processors. Almost by necessity, companies and facilities are forced into incremental improvements. Overall, incremental projects appear to be easier to schedule, can be timed to avoid conflicts with marketing requirements or production schedules and demands and offer immediate compliance benefits. That said, given California's ambitious environmental goals, it is clear that transformative technologies will be needed to ensure that California industries have, at the least, a modest chance at meeting these targets. CLFP urges the Energy Commission to think outside the box in pursuing transformative technologies. A thorough understanding by CEC

APPENDIX B: QUESTIONS AND ANSWERS FROM JANUARY 25, 2018 STAFF WORKSHOP TO DISCUSS PROPOSED FY 2018-19 NATURAL GAS RESEARCH INITIATIVES

researchers of an industry's needs will aid in the determining which types of transformative technologies offer the most promise.

Energy Commission Response

We will consider your comments as we plan future solicitations. With regard to advanced technologies, we currently have an industrial roadmap underway to help identify specific priority research needs and technologies on the electricity-side that have the most promise for implementation in the near and mid-term. We also have a similar activity on the natural gas side focusing on identifying advanced technologies and strategies to improve performance and reduce energy costs in the food processing industry. Both of these documents can help inform future needed industrial energy efficiency research. In addition, we will consider holding public workshops to inform the industry of the results from these studies, but also to obtain stakeholder input on industry needs and consideration of additional advanced technologies. Examples of on-going research associated with food processing industry can be accessed by searching the Energy Innovation Showcase database: <http://innovation.energy.ca.gov/>. The Energy Commission has recently created a webpage for a new program called the Food Production Investment Program, which targets energy and greenhouse gas reducing projects for the food processing industry. For more information: <http://www.energy.ca.gov/research/fpip/index.html>.

Comment:

The current price of natural gas may be low, but it remains an expensive commodity in California due to the enormous costs of transport for industrials. As recently as last year, a CPUC decision more than doubled the cost for the transportation of natural gas. This decision effectively eliminated any benefits that may have been available due to declining commodity costs. Many thermal-based industrial facilities are still trying to deal with this cost increase. Yet, late last year a new proceeding was filed, requesting an additional 30% increase. At this time, CLFP is unsure whether there are any technologies with sufficient promise to offset ever-increasing rates for natural gas. However, the recent Scoping Plan update identifies renewable natural gas as one area that presents promise as an alternative.

CLFP recommends the Commission take a serious look at Renewable Natural Gas as a viable alternative with an eye to development of an infrastructure design that would facilitate increased usage by industrials, possibly stabilize rates, and offer fuel-switching options to industrial users.

Energy Commission Response:

The Energy Commission has been supportive of advancing biogas or biomethane production from various organic wastes including wastewater from food processing industries, food wastes, agricultural residues, including livestock manure, and woody biomass. The Energy Commission has sponsored, both under the Electricity R&D program and Natural Gas R&D program several research projects focused on both biological and thermochemical conversion of organic residues. The goal of this research is to develop and demonstrate new technologies while improving efficiency, reducing costs and reducing environmental impact compared to conventional systems. Recently, there has been a focus on

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agricultural residues in the Central Valley, so for the 2018-19 plan, a proposed initiative under the Renewable and Advanced Generation will support production of renewable fuel from such residues found in the region.

Past research on biogas projects associated with the food production industry, can be found at the Energy Innovation Showcase: <http://innovation.energy.ca.gov/>

Comment:

CLFP has noted the effort by the Commission and staff to introduce reforms to program designs and solicitations aimed at streamlining the process for participation by industrials. New requirements should reflect an understanding of the limitations and market pressures of the industry or facility being targeted, for instance, the seasonality issues central to food processors. Additionally, the ability to stack incentives across agency offerings would be key to increasing participation by industrials. Upgrades and retrofits are expensive, and it is absolutely vital that these endeavors pencil out financially.

Energy Commission Response:

We are working with the Emerging Technologies Coordinating Council to identify strategies for including promising research projects into energy utility program offerings. Pacific Gas & Electric Company, San Diego Gas & Electric Company, Southern California Edison Company, and Southern California Gas Company administer the Emerging Technologies program under the auspices of the California Public Utilities Commission. In the past, some demonstration sites participating in our grant program have also received funding or technical assistance from the investor owned utilities (IOUs) through their Emerging Technologies programs. If the IOU funds are in line with the goals and purposes of the Energy Commission R&D program, then the IOU program funds can be used as match funding for our grants. However, Energy Commission R&D funds cannot fund commercially available technologies that have been well established and proven. As the IOUs are planning future programs and activities, it is important to also inform them of your industry needs.

Comment:

Call me. Email me. Drop by my office. CLFP is always open to working with CEC staff and researchers on issues affecting food processors and the food processing industry.

Energy Commission Response:

We appreciate the willingness of CLFP staff to work with Energy Commission staff.

Gallo Glass (Email #3)

Comment:

Gallo Glass Company is a significant stakeholder in California's glass manufacturing industry, and one of just four remaining glass plants in the state. We are a natural gas customer and seek to reduce our natural gas use, as well related greenhouse gas emissions, while remaining competitive in a global market. Programs like the proposed Industrial, Agriculture, and Water Efficiency initiative can provide valuable funding to accomplish this.

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Gallo Gas Company seeks to offer the following comments, particularly as they pertain to the proposed Industrial, Agriculture, and Water Efficiency initiative.

Fewer, yet larger awards would be more impactful on reduction of greenhouse gas (GHG) emissions, and would likely increase program participation across the industrial sector. For many large manufacturing operations, the cost to install energy efficiency projects can be very high --\$5 to 10 million+ is not uncommon for an individual project. These larger projects, of course also result in the greatest reduction in natural gas and GHG emissions. We also recognize the inherent risk to the California Energy Commission of awarding fewer, larger awards. To mitigate that risk, we propose that the California Energy Commission offers a tier of funding in FY 2018-2019 that would award funds up to \$500,000 for engineering design and review, consultant fees for site planning, and/or costs for related business plans and feasibility studies, which would help to demonstrate the technical merit and benefits of the proposed project. If grant funding supported these efforts now, in future funding rounds, applicants could better demonstrate project results and viability and give the California Energy Commission higher confidence in funding deployment, research, and demonstration project awards at higher levels. Our minimum recommendation would be to increase the grant funding maximum award for these projects from \$1.5 to \$5 million.

Energy Commission Response:

We appreciate your comments. We believe this is a workable approach and will consider in future solicitations

Comment:

The scoring criteria in previous programs related to spending grant funds in California and the restriction of funding not being allowed to be spent outside the United States puts applicants who seek to invest in innovative and emerging technologies at a disadvantage if the technology is only available from manufacturers outside of California, or the United States. Many, if not most, innovative technologies for Energy Intensive Trade Exposed (EITE) industries like container glass making, come from Europe and other countries. Limiting grant spending only to the U.S. severely hampers a company's ability to take advantage of innovations that come from outside the U.S. This limitation does not allow for a truly global view of the opportunities that may exist to reduce energy use. Gallo Glass recommends that if an applicant can effectively prove that there is no ability to purchase equipment in California or the United States that an exemption is included to allow for grant funding to be spent in this manner.

As it relates to the scoring criteria, Gallo Glass recommends that the applicant receive the full scoring consideration for this section, if they can prove that the technology is not available in California. This would also apply to the California Based Entities Preference Points, allowing applicants who cannot purchase equipment in California to be considered for full scoring points in this section, if their business is located in California. This would better encourage large, manufacturing (i.e. EITE) applicants to participate in the program.

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Energy Commission Response:

We appreciate your comments and will consider your suggestions. We need to balance the fact that funds come from California ratepayers and we want to maximize funds spent and benefits in California, but at the same time, we realize that such limitations could hamper opportunities for innovative and transformative research and products.

Comment:

Handling of Confidential Business Information (CBI) should be amended in future grant application forms. We recommend removal of the language, "The application does not contain any confidential information or identify any portion of the application as confidential." There must be an allowance that certain sections of the application will be confidential and not subject to public dissemination. For many, if not most companies, the details of its specific business performance is CBI, as it can provide competitors information that could disadvantage the applicant. Other state and federal grant programs provide a mechanism for this type of confidential information and we believe these CEC grant applications should as well. Without making this change, the program inherently advantages public entities and disadvantages private entities from applying.

Energy Commission Response:

As these are public funds, the application process and research results are considered public information. Our application process does not require financial statements but it does require budget information about the project, such as labor rates, fringe benefits, overhead, etc. This information is public information and subject to public records act request. For any deliverables, we are not interested in obtaining trade secrets, formulations, designs and blueprints of technology, etc. Once the grant is in place, there is a way to request that certain deliverables be held in confidence, but our attorney and executive director make the final determination on regarding whether they should be considered confidential.

SoCalGas (Email #4)

Comment:

The industrial market sector will be interested in both incremental improvement technologies that can contribute to their near term financial and environmental improvement objectives and longer term transformative technologies that can help them achieve California's aggressive greenhouse gas (GHG) and criteria pollutant reduction goals. However, industrial operators will likely be constrained in their investments in higher risk research due to limited research funding and therefore rely on incentives to provide the majority of funds for the development and demonstration of these new technologies.

Energy Commission Response:

We appreciate your comments and will consider your suggestion to include both incremental and transformative technologies.

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Comment:

Commercial food service cooking equipment generally needs to be improved to increase energy efficiency and reduce both GHG and NOx emissions. Current cooking equipment has never been subject to minimum efficiency standards or mandates for control of criteria pollutants such as oxides of nitrogen (NOx) and particulate matter (PM). As a result, most cooking equipment still use older atmospheric type burner technology with uncontrolled NOx levels. In the 2016 South Coast Air Quality Management District (SCAQMD) ozone reduction plan, Control Measure CMB-04: Emission Reductions from Restaurant Burners and Residential Cooking was adopted which sets a goal to reduce NOx emissions by 50% for this category of equipment. Specific NOx emission targets will likely be set in future air district regulations. In addition, Control Measure BCM-01: Further Emission Reductions from Commercial Cooking was adopted to reduce particulates from underfired charbroilers. The CEC should consider research programs to address these new NOx and PM emission reduction goals for commercial food service equipment in SCAQMD.

In addition, the 2016 SCAQMD ozone reduction plan also adopted several other Control Measures to reduce NOx emissions further. CMB-02: Emission Reductions from Replacement with Zero or Near-Zero NOx Appliances in Commercial and Residential Applications will push for the development of zero or near zero NOx emission residential appliances including water heaters and space heaters. The CEC should consider research programs to address the need to reduce NOx from residential appliances below today's current regulations.

Energy Commission Response:

We will consider your suggestions for research to improve energy efficiency of cooking and other appliances while also reducing NOx and PM emissions for food service and residential appliances in future budget plans. For the 2018-19 plan, CPUC resolutions G-3519 and G-3527 instructed the Energy Commission to focus on research solutions to help industries covered by the Cap-and-Trade program because they are emissions intensive and trade exposed (EITE) and could potentially relocate outside of California. As a result, the focus of the 2018/19 year will be on industrial facilities. Future research initiatives could consider food service and other appliances. However, the Energy Commission has funded much research and demonstration on high efficiency food service appliances. The following are examples of current research on appliances and equipment that focus on energy efficiency and NOx emission reductions:

- Demonstration of an ultra-low-NOx burner for a commercial boiler at Mission Linen in Santa Barbara (GTI – PIR-14-004). The burner uses a novel design called dynamic stage entrainment to reduce fuel usage while keeping NOx emissions low. After more than a year of operation, the boiler has shown a nearly 10% annual fuel savings and a NOx emissions reduction of greater than 70% compared to baseline testing. The emissions limits for these types of boilers are 9 ppm NOx corrected to 3% O₂.
- Demonstration of various commercial food service appliances that can improve overall cook line efficiency and validate energy savings and use of commercial

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kitchen ventilation optimization techniques (Fisher-Nickel – PIR-14-008). The objective is to encourage the kitchen design and food service community to adopt these advanced efficient appliances versus standard commercial kitchen lines. The project also characterizes cooking equipment NOx emissions for the baseline and high efficiency replacement cooking equipment.

- Demonstration of residential gas-fired heat pump water heater (GHPWH) which integrates a small, gas-fired, single-effect, absorption heat pump with a hot water storage tank, resulting in a projected Uniform Energy Factor of 1.30 (GTI – PIR-16-001). The GHPWH is projected to meet the Ultra Low NOx emission requirements set by the South Coast Air Quality Management District's Rule 1121 of 10 ng NOx/J output.
- Development and demonstration of an innovative, low cost gas heat pump for integrated Commercial Hot Water (CHW) and air conditioning at two full service restaurants (GTI – PIR-16-004). The commercial restaurant industry typically has large hot water loads, and greater internal heat gain from occupancy and kitchen equipment. The project seeks to demonstrate 40% therms savings and offset 20% or more of the annual air conditioning cost.

Comment:

Past CEC research has been successful in getting industrial customers to participate in demonstration of new gas technologies. Several ongoing demonstrations include the following: demonstration of the ribbon burner technology at Western Bagel, demonstration of an advanced industrial dryer at Martin Feed, demonstration of an advanced burner/boiler technology at Mission Linen (in Santa Barbara), and demonstration of an advanced heat recovery technology at Mission Linen (in Oxnard). However, providing more time for applicants to respond to CEC solicitations will improve industrial customer participation. Currently, the short time schedules provided in CEC solicitations are not adequate for many potential industrial host sites to fully investigate/explore their interest in joining demonstration projects.

Energy Commission Response:

Most of our applications are typically due six to eight weeks after solicitation release and we realize that by extending the application period, recipients could minimize the need for future demonstration site changes. In some recent solicitations, we have extended the application period to provide ample time to secure demonstration projects. The Energy Commission is also proposing to the CPUC consideration of a three year funding cycle, similar to EPIC, and this could result in more time for the application period.

Comment:

CEC research programs greatly benefit from close collaboration with California Independently Owned Utilities (IOUs) in identifying industrial / commercial host sites for technology demonstration projects. SoCalGas maintains an active staff of Account Executives that call on all larger industrial customers. These personal relationships, between SoCalGas and our industrial

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clients, provide an excellent way to communicate and acquire participation in research demonstration projects.

Energy Commission Response:

We appreciate this coordination with your industrial clients.

Comment:

The CEC should consider providing more time for applicants to respond to CEC solicitations to improve industrial customer participation. Currently, the short time schedules provided in CEC solicitations are not adequate for many potential industrial host sites to fully investigate /explore their interest in joining demonstration projects. In addition, the CEC should review their current policies on approval of modifications to accepted proposals. Typically, the projects at these large and complex industrial facilities are themselves large and complex, requiring significant planning and engineering. Through that process, identifying new information and obstacles is more the rule than the exception, so the ability to nimbly adapt is valuable for the sake of progress. However, under current CEC project funding practices, changes to a proposal more often require a formal CEC review with Board approval that can take up to one year. This, along with formidable accounting requirements, can discourage some parties from applying for funding. Whatever process CEC can bring into place to reduce the time to review and approve necessary project changes and simplify accounting requirements could increase the number of projects proposed and the number of interested, qualified lead investigators.

Energy Commission Response:

See previous comment regarding expanding the application period. With respect to amendments, we have streamlined the approval process for requesting amendments. For instance, many amendments can now be handled either at the R&D Deputy Director level or below. This should result in quicker approvals of amendments.

Comment:

CEC should consider funding follow-on demonstration projects to further validate new technologies and to assist with early commercialization efforts. Typically, advanced burner technologies may be applied to many different industrial equipment and funding demonstrations in multiple applications can help manufacturers expand their sales potential into many markets.

Energy Commission Response:

Under the Energy Commission's proposed expansion, we have considered an initiative called BRIDGE (Bringing Rapid Innovation Development to Green Energy), which provides follow-on funding for projects with technical and economic promise that could benefit from additional funding to expand and deploy. This Bridge initiative will be similar to the one occurring on the EPIC program. Refer to GFO-17-308:

<http://www.energy.ca.gov/contracts/epic.html#GFO-17-308>.

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Comment:

Past CEC research awards in the \$750,000 to \$2,000,000 range have been adequate to support the majority of new technology demonstration projects. Larger awards, in the \$3 to 6 million range, would probably be of interest to large industrial operators, like refineries and power plants, to help fund some of their facility improvement projects.

Energy Commission Response:

We will consider your comment.

Comment:

Technology adoption could be improved by funding incentive programs to promote the purchase of new equipment /technologies by early adopters. In addition, funding support of multiple demonstrations of new technologies can provide operators with additional confidence that a new technology will work well at their facility. Finally, funding for longer term M&V of the installed technology to answer potential users' questions of technology longevity and ability to integrate into industrial processes may help in longer term and wider spread adoption of the technology.

Energy Commission Response

Funding for multiple demonstrations was discussed previously regarding participation in the BRIDGE solicitations. Though longer measurement and verification (M&V) periods are desirable to ensure sustainability and persistence of savings, often we are limited by the liquidation date for the research funds and cannot extend agreements beyond that date. The typical term is less than four years.

Renewable Energy and Advanced Generation Research Initiatives:

Julia Levin: Bioenergy Association of California

Workshop Comment #5:

It goes without saying we strongly, strongly support this research area, and I think you are asking the right questions, but this is far, far too little funding to begin answering most of these questions. If you think about the gas sector as a three legged stool, one leg is gas safety and improving that, one leg is increasing efficiency, and the third leg is increasing renewable gas to displace fossil fuel gas over time. The third leg is getting really short shrift. In this strategy you're only allocating one eighth of all the dollars to the third leg of the stool. This particular area, renewable gas, is also absolutely central to achieving the requirements of SB1383. I don't see any way to do that with just three million dollars. Part of the reason I was asking earlier about why the agricultural waste energy isn't included in the agricultural section is, we strongly support the inclusion of forest biomass and ag/livestock waste in this section, but then you have left out the entire urban waste stream. Which right now is focused on anaerobic digestion but according to CalRecycle, the vast majority of the organic landfill waste stream is non-digestible organic; it's wood waste it's construction debris, it's the 8 thousand structures in the wine country that

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partially burned. And, now all of this waste is going to go to landfill instead of energy facilities, for a whole number of reasons, one being we haven't figured out gasification yet in this state.

Energy Commission Response:

Thank you for your input. We will take that into consideration as we move forward with opportunities to produce renewable natural gas R&D from California biomass sources.

Regarding your comment on the funding amount relative to the effort needed to achieve the SB 1383, when proposing the research initiatives and funding levels, Energy Commission staff considers other State and local funding programs positioned to yield short-term reductions in short-lived climate pollutants. The allocation for Renewable and Advanced Generation is consistent with prior years.

Karen Mills – California Farm Bureau Federation

Workshop Comment #6:

Julia made some really good points and appreciate her comments. I have questions related to the biomass projects. The woody biomass project has become a problem over the years. As you pointed out with many biomass closures; The project that is being conducted at UCSD and the results from that, so how do you tie what you are seeing there - and adding onto the projects right now - are there lessons you'll be able to build from that will make the woody biomass project successful and feasible?

Energy Commission Response:

Thank you for your comment. That project in particular with UCSD helping develop technology for converting woody biomass to methane, it is currently at an early stage research using small bench scale system. We are also supporting development of another small gas conversion technology in Berkeley. We are keeping track of the results and lessons from these R&D projects to support building successful commercial scale systems in the future.

Bloom Energy (Email #5)

Comment:

Bloom supports the research initiative addressing *Improved Functionality and Readiness of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities*. We particularly agree with the language as written on slide 35 showing that the scope includes both natural gas and biogas fueled systems (e.g. “clean and efficient distributed generation, including biogas-fueled systems”). Additionally, the stated goals of this program include “Developing hybrid, fuel-flexible, energy efficient, and low emission DG technologies for natural gas and alternative fuels including biogas.” Because the alternative to advanced distributed generation systems at critical facilities and in remote areas would most often be diesel or propane fired generators, both RNG fueled and natural gas fueled clean and efficient advanced distributed generation with superior functionalities that would obviate the need to use them would confer environmental benefit. These benefits would be further enhanced by using a non-combustion technology such as a fuel

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cell that has near-zero emissions of criteria pollutants and particulate matter. We request that the rest of the language describing this research initiative, including the questions posed and answered below, reflects this fuel diversity.

Energy Commission Response:

The Energy Commission acknowledges the importance of fuel diversity, and has crafted the initiative language to include both natural gas and biogas as eligible fuels for this initiative.

Comment:

One of the most important functionalities that would address the needs of fire risk regions and critical facilities is the ability to grid island and continue to serve onsite load in the event that the electrical grid goes down for extended periods, whether from damage or from proactive shut off such as de-energizing a circuit during high wind events to avoid the ignition or spread of wildfire. Among many other things, access to electricity is important for communications infrastructure that first responders and citizens rely on for accurate safety information, for shelters and community centers where affected communities can congregate and find food, water, and other essential resources, and for hospitals to continue serving their communities. A clean advanced generation system (defined as a system that lowers GHGs, lowers criteria air pollutants, or both) that could supply continuous power while the grid is down for extended periods would ensure that these facilities are operational and continue to provide their essential services. Utilization of either natural gas or biogas in advanced technologies would provide significant benefit so long as the technology is proven to exceed the efficiencies of the technologies it is displacing.

Grid islanding capability for extended periods of time is also an important resource for grid operators. Knowing that there are critical facilities that continue to have power, where those facilities are, and how long they can continue to operate without grid service can relieve constraints on the logistical challenge of getting a regional grid back up and running, leading to faster restoration of service.

Energy Commission Response:

The Energy Commission also acknowledges the importance of grid islanding capability. As with previous research plans, it is worth noting that the research initiative does not present an all-inclusive list of features and technologies that may be funded. Instead, examples of possible technologies and strategies that could be funded are provided. The Energy Commission will consider including grid islanding capability as one of the desired “advanced functionalities” when the solicitation is released.

Comment:

Having an onsite fueled DG resource is ideal when there is a requirement for a relatively large amount of power (more than 50 kW) and/or for a long duration (more than a few hours). If a facility wants to ensure an electricity supply for extended durations, relying solely on storage that is storing grid electricity and cannot recharge while the grid is down is not a tenable solution. Clean fueled DG resources, especially those that are connected to the natural gas system and can therefore have a long duration and a high reliability fuel supply, are a better solution.

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Energy Commission Response:

The Energy Commission acknowledges that there are certain advantages of natural gas-fueled DG systems over energy storage, especially when considering long duration reliability. However, there are disadvantages and trade-offs as well. These trade-offs are expected to be explored as we develop this research initiative into a solicitation.

Comment:

Storage operating in concert with fueled DG systems can serve facilities with complex load curves (e.g. with variable peaks of demand) where the fueled resource can serve a baseload function while storage serves the peaks. If the storage is configured to charge from the fueled DG resource while the grid is not operational, then this will be possible for extended durations as well. If the storage does not charge from the DG resource, then the ability to serve peaks will only last as long as there is remaining grid electricity stored.

Energy Commission Response:

The Energy Commission acknowledges the ability of DG and energy storage to operate together better to serve facilities with complex load curves. The Energy Commission expects and encourages projects proposed under this initiative to include energy storage along with DG, though it does not expect this to be a strict requirement.

Comment:

While this question is addressing the *Central Valley Agricultural Waste Resource to Energy* research initiative, it is applicable to developing advanced distributed generation for critical facilities in the Central Valley as well. Put simply, electricity generation technologies that have near-zero emissions of criteria air pollutants and particulate matter would have significant impact on improving local air quality. The electricity can serve a variety of onsite loads without air pollution dispersing into local communities, can displace the need for generation from centralized gas plants in the Central Valley thereby reducing basin air pollution, and can support electrification efforts in the transportation sector to eliminate emissions from mobile sources.

Energy Commission Response:

Regarding air quality in the central valley, the Energy Commission acknowledges the potential contribution that clean and efficient distributed generators could have on improving air quality. However, as stated in the Central Valley initiative, projects are expected to demonstrate a “whole system approach” from feedstock to end use. A system utilizing fuel cells for power generation could be eligible, but only if the feedstock to power said fuel cell is sourced from central valley farm biomass resources.

SoCalGas (Email #4)

Comment:

The CEC plan identifies thermal storage and utilization as an enabling technology for increased micro-combined heat and power (MCHP) development. While this is certainly helpful, it has been our experience that the complete lack of MCHP product options is due to difficulties meeting

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emissions standards. These standards, in the case of MCHP, are not local air district standards but are statewide California Air Resources Board (CARB) Distributed Generation (DG) standards. SoCalGas has been instrumental in conducting outreach to MCHP vendors worldwide, collaborating with entities such as GTI, and has tested MCHP products at SoCalGas labs. Furthermore, the CEC plan does not address MCHP in residential markets. We have done outreach with several multifamily builders and have found that they are completely unfamiliar with MCHP. SoCalGas has also been engaged in product testing for MCHP at single-family residential scale, testing a 1.5 kilowatt (kW) fuel cell with thousands of installations in Europe at the University of California, Irvine.

SoCalGas has a long history of successful collaboration with the CEC and is very active in supporting CEC solicitations with a variety of activities including; outreach to potential applicants to increase the depth and breadth of applications, co-funding and supporting applications, and outreach to SoCalGas customers in order to locate ideal demonstration sites. GFO-17-501 is a great example of this; SoCalGas supported and co-funded all awardees in Group 3: 'Develop and Demonstrate Near-Zero Emission Small and Micro-Scale Distributed Generation Systems'. All three products to be demonstrated have been involved with SoCalGas for years, two of the products have been tested by SoCalGas, and SoCalGas will host one of the demonstrations.

Energy Commission Response:

The Energy Commission appreciates and acknowledges the comments and suggestions provided by SoCalGas, and looks forward to continued support. Staff appreciates the range of suggested research topics in the area of renewable and advanced generation. While staff find them interesting and needed, funding availability will limit us to specific priority areas.

Natural Gas Infrastructure Safety & Integrity:

**Steve Golan – U.S. DOE Lawrence Livermore National Laboratory
(Advanced Energy Technology Program)**

Workshop Comment #7:

You talk about understanding mechanical failure and preventing mechanical failure, sort of on the basic science and emerging research is understanding materials and how they fatigue and age, and also new technology that actually provide reporting information about its state. Need to understand how materials fatigue and fade and consider research on understanding how materials can report their state in regards to corrosion, etc. Is there possible moving forward going this direction where they automatically report their state?

Energy Commission Response:

We would be open to these ideas so if you could write it down in your comments that would be great.

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Karen Mills – California Farm Bureau Federation

Workshop Comment #8:

I want to follow up on some of the comments that Todd made as well as growing food in California. Farmers sustain a great deal of energy infrastructure on their land that they have to operate around the sensors that you talked about. The equipment was real intriguing to me obviously seeing everyone's space and operating around natural gas lines, and then identifying the depth. So as you peruse some of these and the research opportunities with new technology for the sensors, and find a tool or methodology that allows a better identification for the depth of these. So the accuracy of this technology would be very helpful for the safety of people.

Energy Commission Response:

Thank you. We agree that the depth is something that we need to capture.

Mark Bishoff – Lorax Systems (WebEx):

Workshop Comment #9:

We have been working with the Gas Technology Institute in Chicago for a number of years and we now have two technologies that we are testing at GTI for the purpose of dealing with third party damage. Backhoes are certainly a part of that but there are many means to third party damage when it comes to from distribution, transmission, and service lines. And this technology has been advanced over the last four years, and now in the third quarter of this year this technology should be available for the utilities to look at and investigate. When this technology is activated, it shuts off the flow gas to very low pressure to very high pressures.

Energy Commission Response:

Thank you for your comment. We invite you to send information to us so we can look at your technology.

Southern California Contractors Association (Email #6)

Comment:

The Southern California Contractors Association (SCCA), supports the "Natural Gas Infrastructure Safety & Integrity" research and development efforts proposed for 2018-19. SCCA is an all-union association of engineering contractors primarily located in the Southern California region. They primarily engage in construction activities that cause them to interact with existing underground infrastructure.

As you know, great risk exists for contractors and others that excavate around any underground infrastructure, especially high-pressure natural gas lines. The research the commission conducts supports SCCA's goal of increasing the safety of working around this infrastructure.

SCCA members have vast experience in working below the surface. One of the biggest concerns they share is the inability to adequately identify the depth of the infrastructure even

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after the utilities have identified their location. The depth of the infrastructure may be required in regulations, but there is no guarantee. Developing some device to positively identify underground utilities, especially high-pressure natural gas lines, would be an excellent use of R&D resources.

I thank you for the opportunity to address you at the workshop and I am committed to further working with the commission to provide the excavator's perspective.

Energy Commission Response:

The Energy Commission agrees that inexpensive sensors (either fixed or portable) to identify natural gas lines is valuable and is an element of the planned research.

SoCalGas (Email #4)

Comment:

We agree the CEC's current portfolio and proposed funding initiatives are addressing key safety and integrity objectives. We recommend revising the goals to specifically reference the enhancement of "system integrity". Concerning the most critical area of pipeline safety and excavation damage prevention one additional area of work could be in the area of preventing pipeline damage on private property where "One Call" requirements are not mandated and where system damages frequently occur.

Energy Commission Response:

The Energy Commission agrees that integrity is fundamental to system safety and captures this in the proposed budget plan. Our slide has been update to specify "system integrity".

SoCalGas routinely leverages the collaboration funding mechanisms achieved through participation in research and development consortiums, such as the Pipeline Research Council International (PRCI), NYSEARCH, and the Operations Technology Development (OTD) organizations. These consortiums provide opportunities to gain synergies in research efforts with other utilities across the nation and benefit from learning of initiatives from members in other states or other countries. These organizations routinely partner with academics and industrial partners to perform a wide variety of RD&D projects. This approach helps to provide a greater diversity of ideas and solutions to improve the possibility for success.

Energy Commission Response:

The Energy Commission appreciates the additional suggestions for growing the research community.

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Energy – Related Environmental Research:

David Huang – California Public Utilities Commission

Workshop Comment #10:

I noticed that in the central valley agricultural waste resources to energy initiative, there was a bullet that stated that the technology should focus on maximizing energy and air quality, and I was wondering how would this build on the current research being done that is being described by Mr. Hou. Is there an opportunity to build off or leverage findings from agricultural initiative and environmental GHG measuring initiative for RNG projects?

Energy Commission Response:

We do have a small handful of small gas fires that we can build on, on our upcoming initiative. So, we do have some cooperation there.

Bud Beebe – CA Hydrogen Business Council

Workshop Comment #11:

I think out of necessity these programs will be measuring emissions to sort of understand the larger term and looking at air emissions typically. Now the biomass projects have such tremendous capability to reduce other environmental effects that currently occur in agricultural areas. I think this tends to get swallowed when we concentrate just on looking say at short term greenhouse gas. That's a good thing to think about, and we need the Energy Commission to have good public information available. But it would be wonderful if in all of these, that these projects have greater environmental enhancement capabilities. Instead of just talking about specific emissions or emissions alone, it would be beneficial to mention these projects have much greater environmental impacts and benefits. It would also be helpful to have multi-agency coordination for emission, water benefits, etc.

Energy Commission Response:

The CEC definitely agrees that a lot of those projects have many great benefits. For us, an accurate measurement of emissions before and after will be better.

Bloom Energy (Email #5)

Comment:

As evidenced by the passage of AB 398 and AB 617, ensuring that all communities achieve high air quality is a priority of the State and should be incorporated into research considering the development and end uses of renewable natural gas. This principle complements seeking out low carbon solutions to achieve our environmental goals as well as clearly prioritizes maintaining public health and equity. The air pollutant analyses should at minimum include NOx, SOx, and particulate matter.

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Additionally, while the stated main objective is *“to measure overall emissions and compare them with estimates to better quantify the benefits from RNG projects,”* we encourage the Commission to include a broader study of the potential for emissions impacts from RNG projects within the scope of this research initiative. Specifically, this initiative should include examining and comparing emissions impacts of various end uses of the RNG, such as combustion in mobile engines for transportation, combustion in stationary engines for electricity generation, and non-combustion electricity generation in a fuel cell. This understanding will complement the analysis comparing public health impacts of combusting upgraded RNG versus natural gas that is also mentioned in this initiative.

Taken together, this information will provide policy makers with a more robust basis for making sound decisions that will lead to the greatest environmental and public health impacts as the RNG supply increases and more RNG projects develop over the coming years.

Energy Commission Response:

Criteria air pollutants such as NO_x, SO_x, VOCs, and PM will be considered. However, depending on the specific site and application, perhaps not all of them will be measured. As discussed in the workshop presentation, the Energy Commission plans to conduct additional research based on the preliminary results from a current project (PIR-13-001) to further investigate the public health implications from combusting RNG versus petroleum natural gas.

Research and development of carbon capture strategies and technologies closely ties into the Energy Related Environmental Research program goal to *“explore how new energy applications and products can solve/mitigate environmental problems.”*

Innovative approaches to separating and capturing CO₂ from exhaust streams of gas-fueled technologies have the potential to significantly reduce GHG emissions from the use of natural gas and provide a pathway to negative emissions when coupled with the use of renewable natural gas. We encourage the Commission to include the development of carbon capture approaches in its plans to mitigate the environmental impacts of fuel use, specifically with respect to advanced distributed generation technologies. This focus on distributed technologies complements the initiative within the Renewable Energy and Advanced Generation program to *Improve the Functionality of Advanced Distributed Generators for Fire Risk Regions and Critical Facilities*. The parallel development of these two initiatives would increase the probability that technologies that are developed for critical infrastructure could adapt and incorporate this environmental capability as it matures and becomes widely available.

Energy Commission Response:

Carbon Capture and Sequestration using flue gases from natural gas combustion is a very expensive research area that has been traditionally supported by the U.S. Department of Energy. If additional funds become available to the Natural Gas Research Program, the Energy Commission may explore the feasibility of supporting this type of research and demonstration. Potential environmental impacts such as induced seismicity may also be explored.

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Bluefield (Email #7)

Comment:

The natural gas sector must continue to innovate and evolve if it is to play a positive role in achieving California's climate change goals. To this end, we are pleased to see the Energy Commission presenting such a strong, multifaceted agenda for the Natural Gas R&D Program, as well as a proposal to expand funding further for this important work.

Ensuring the success of this agenda will require leveraging the latest innovative technology developments. In particular, the Commission should seek to incorporate new solutions emerging from the intersection of energy, big data, and the revolution in low-cost microsatellites.

There are clear synergies between Bluefield's sensor development and the Commission's proposed 2018-2019 research agenda, and we hope to find ways to participate. Previous grants by the Commission to NASA/JPL for research conducted with their Airborne Visible InfraRed Imaging Spectrometer – Next Generation (AVIRIS-NG) establish a strong precedent, and we hope that upcoming research solicitations continue to incorporate emerging technologies.

There may also be an opportunity for Bluefield to contribute to the Natural Gas Infrastructure Safety and Integrity area, as part of the proposed "Developing Sensors for Pipeline and Storage Damage Prevention" project. Our sensor could complement stationary sensor approaches by detecting pipeline and storage infrastructure leaks from an aerial platform, potentially offering more comprehensive geographic coverage at a far lower cost. In collaboration with utilities, this initiative could utilize our data in combination with other data streams to develop improved analytics for predicting infrastructure integrity issues.

Energy Commission Response:

The Energy Commission has funded several different methane emission measurement methods and will continue to support research to reduce methane emissions from California's natural gas system. The Energy Commission will also continue to monitor the technology development in this field and ensure the best science is used to reach the State's environmental goals. If additional funds become available for the Natural Gas Research Program, the Energy Commission may explore the feasibility of supporting this type of research.

Healthy Building Research (Email #8)

Comment:

I noticed that IAQ & ventilation was on the agenda for the Jan. 25 workshop, but I did not see that topic addressed in presentations. What are the status and plans for those projects?

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Energy Commission Response:

The Energy Commission has several active research projects funded through both the EPIC and Natural Gas research programs (EPC-15-003, EPC-15-037, PIR-14-007, and PIR-16-012). In last year's workshop, one IAQ project was highlighted in the presentation (500-09-042). The final report for that project has been posted (<http://www.energy.ca.gov/2017publications/CEC-500-2017-034/CEC-500-2017-034.pdf>). IAQ research remains one of the important topics in environmental related research. The Commission will continue to support research in this area.

Natural Gas – Related Transportation Research

Julia Levin - Bioenergy Association of California

Workshop Comment #12:

Would like the California Energy Commission to consider one small addition of renewable gas to natural gas for transportation use on a larger scale.

Energy Commission Response:

We agree that this is an area we should look at.

SoCalGas (Email #4)

Comment:

SoCalGas agrees that the California Energy Commission (CEC) is prioritizing the right initiatives to advance the science of natural gas-related transportation technologies. During the workshop held on January 25, 2018, the proposed initiatives for Natural Gas-Related Transportation Research included the following:

- Develop High Efficiency, Low Emission, Production-Ready Natural Gas Engines for Long Haul Applications
- Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel

These two areas are critical in the development and advancement of natural gas-related transportation technologies. SoCalGas has had a long relationship with the CEC in developing natural gas-related transportation technologies and has been greatly successful with the development and commercialization of the Cummins Westport, Inc. (CWI) 8.9L and 12L near-zero emission engines. It is well known that natural gas engines are relatively 10-20% less efficient than their diesel counterparts, but make up for it with lower NOx emissions, more than 90% cleaner with near-zero emission engines. SoCalGas feels that it is necessary for the CEC to prioritize these two areas, but emphasize more on achieving comparable performance to diesel. Natural gas vehicles have been proven to emit lower NOx emissions and with the combination of

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RNG, can further reduce GHG emissions thus achieving California's air and climate quality goals faster. SoCalGas can encourage natural gas technologies directly to its customers and increase the commitment from fleets and truck operators to transition to natural gas and achieve California's air and climate goals.

Energy Commission Response:

The Energy Commission thanks SoCalGas for supporting the development of the now commercialized near-zero emission engines and continuing to support the two proposed FY2018-2019 research initiatives. The proposed initiative on "Research Natural Gas Compression Ignition to Achieve Comparable Performance to Diesel" responds to the need to continuously improve the performance of natural gas engines while maintaining low NOx emissions.

Comment:

Research in engine design and new materials for catalysts would greatly benefit natural gas vehicles. Current natural gas engines have started out as diesel engines that have been recalibrated and re-engineered to run on natural gas. It would be of interest to investigate an engine built specifically for natural gas that takes into consideration the thermodynamics and mechanics of an engine operating on natural gas. Other areas to take into consideration are to promote more manufacturers to produce and commercialize near-zero emission engines.

Currently only one OEM offers a near-zero emission natural gas engine, CWI. In-order to increase economics and growth of the technology, competition is a necessity. SoCalGas is fully engaged in the transportation industry and close relationships with industry partners to help facilitate these technologies.

Energy Commission Response:

Developing an engine built specifically for natural gas as opposed to a re-engineered diesel engine would be of great interest due to the potential for optimizing around the unique properties of natural gas. However, this will require significant investment to achieve a commercial product. Advanced catalyst research may be needed to pair with high efficiency, low temperature combustion technologies to maintain near-zero emissions. The Energy Commission agrees that increased market competition would be beneficial to the continued improvement of natural gas engine technology. The proposed research initiatives will aim to expand the natural gas engine market and develop innovative methods for achieving comparable performance to diesel engines.

Comment:

The CEC should consider areas of research in improving natural gas vehicle infrastructure, cost effective on-board natural gas storage, improve compression efficiencies, and near-zero emission technologies in medium-duty applications. Also, the tri-generation concept where the goal of the system is to reduce the overall carbon intensity in transportation and not limiting or favoring one fuel over the other. The concept of the tri-generation station is to provide transportation fueling infrastructure for compressed natural gas (CNG), Electric, and Hydrogen vehicles at one location.

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The Tri-generation system is a fuel cell system, fueled from RNG that will simultaneously produce electricity, heat, and hydrogen fuel. The electricity produced will be utilized for the electrical loads for a CNG and a hydrogen station (e.g., compressors, dispensers, etc.), electric vehicle fast charging (Level 2 and above), electric power to surrounding facilities and excess electricity will be directed back to the grid. Battery storage will also be utilized to help capture the electricity needed for peaks in electricity consumption during compressor ramp up and electric vehicle charging peaks during electric fast charging.

Battery storage will act as a buffer and peak shaving to reduce peak demand during high usage times.

The hydrogen produced will be utilized to support a hydrogen fueling station serving fuel cell vehicles around the area. Excess hydrogen will be sold/sent to industries with high demand of hydrogen or delivered to other surrounding hydrogen stations.

Since the system primarily runs on RNG, the system can also use natural gas to sustain a consistent fuel flow in case of any disruption in RNG availability or quality. In addition, since power is produced from renewable sources (RNG) greenhouse gas emissions are substantially reduced. Using alternative fuels in transportation such as CNG, electricity, and hydrogen fuel cell also reduces NO_x, GHG, and PM emissions in the South Coast Air Basin. Transportation technologies are rapidly changing and so should the infrastructure that supports the technologies.

Energy Commission Response:

Natural gas fueling infrastructure efficiency and costly on-board storage are important barriers to the adoption of natural gas vehicles. The Energy Commission has previously funded natural gas infrastructure and on-board storage research projects and will consider continued research in this important area. Past and ongoing projects focused on improving the full-fill performance of CNG fast-fill dispensers and low-pressure adsorbed natural gas storage technology. Continued research in this area will be considered in future initiatives.

The tri-generation fueling system is an interesting concept with potential to reduce the overall carbon intensity of several alternative fuel pathways. The Energy Commission will consider this technology concept in the proposed Natural Gas R&D Program expansion, which may include hydrogen and fuel cell-related research.

Comment:

Technology barriers to expand natural gas use in off-road applications are similar to on-road applications. There is a need to achieve diesel like performance as well as larger displacement engines. However, off-road applications require very different engine specifications and duty cycles that need to be closely investigated for natural gas to be successful. Off-road applications span from yard hostlers to construction vehicles to agriculture. These applications typically have higher loads, rough terrain, and long idle times. These barriers include achieving comparable performance and efficiency as diesel engines for higher displacement engines. Technology barriers for off-road applications are not limited to vehicle technologies. Infrastructure for off-road

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applications needs to be developed as well. Since most of these applications are relatively further away from any known infrastructure, cost effective and efficient infrastructure needs to be expanded for off-road applications. These might include mobile refueling stations or more efficient drive systems to accommodate long idle times like CNG-hybrid.

For locomotive and marine applications, the CEC should consider advancements in fuel storage and infrastructure needed for these bigger applications.

Energy Commission Response:

The Energy Commission agrees that off-road vehicles have unique duty cycles and engine specifications that require specialized engine development work to ensure comparable performance to diesel. The Energy Commission is currently funding a project with Terzo Power Systems, LLC to develop a highly efficient CNG-hybrid agricultural vehicle that may alleviate some barriers related to infrastructure and extended idle times. The Energy Commission will also consider future research on advancing fuel storage and fueling infrastructure technologies needed for off-road applications.

Comment:

SoCalGas is committed to advancing and expanding natural gas transportation technologies. The SoCalGas Research, Development and Demonstration (RD&D) portfolio for clean transportation and the CEC research initiatives for natural gas transportation technologies complement each other and are imperative for the success and forward progress of natural gas transportation technologies. SoCalGas has a strong history of partnering with and leveraging funding from state and local agencies as well as federal agencies such as the Department of Energy. Most of these technologies center around engine and vehicle development, where SoCalGas' RD&D and natural gas vehicle (NGV) program has built close relationships with key industry partners to advance areas of research and development along with consumer exposure. However, other areas of SoCalGas' RD&D program are to investigate improved infrastructure and alternative ways where natural gas is used for transportation.

Areas that require more emphasis include achieving comparable performance to diesel. This is an area where natural gas technologies are lacking and needs more development. Closing the 10-20% gap on engine efficiency when compared to diesel should be the first and foremost development effort. As the transportation environment transforms, it is important that natural gas technologies to remain competitive and operate analogous to its counterparts. Another area of emphasis is infrastructure. Infrastructure is still a significant barrier for natural gas transportation as fueling stations are not widely available or easily accessible. Without a growing infrastructure, it would be very difficult for fleets and operators to adopt the technology. Emphasis on lower cost and more efficient infrastructure would help encourage the adoption of natural gas.

Energy Commission Response:

The Energy Commission will continue collaborating with SoCalGas's RD&D program to pursue the advancement of natural gas transportation technologies. Improving engine efficiency and competitiveness is a high priority and will be addressed with the proposed

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research initiatives. The Energy Commission will consider emphasizing research on fueling infrastructure technology to reduce the cost of station deployment and operation in future initiatives.

Comment:

Collaboration and synergies would include research institutes, national labs, technology manufacturers and providers, other governmental agencies, private manufacturers and IOU's.

Continued collaboration is required for the advancement of the technologies, but should not be limited to similar projects.

Energy Commission Response:

The Energy Commission will continue to collaborate with research institutes, national labs, technology manufacturers and providers, other government agencies, private manufacturers, and IOUs to ensure the successful advancement of natural gas transportation technologies.

Comment:

SoCalGas is also focused on reducing both criteria pollutants and GHG's by way of both efficiency improvements and emissions control technologies. We do so in a technology neutral fashion as there are still improvements to be made on technologies that have reached maturity. An example of this would be our work with the company Tecogen, developing an advanced catalyst system which reduces NOx and carbon monoxide (CO) to near zero levels and can be retrofitted onto existing engines.

Lastly, the CEC should add to their list of policy drivers shown on slides 11, 12, and 13, the need to help the various air districts in CA to meet the Federal Clean Air Act Ozone Standard and the need to substantially reduce NOx (a precursor to Ozone) by 50 to 70%.

Energy Commission Response:

Slide 13 has been revised to explicitly mention the need to meet federal health-based air quality standards for ozone and particulate matter. This is one of the critical goals identified in the 2016 Mobile Source Strategy. The Energy Commission's natural gas-related transportation research will continue to focus on advancing near-zero emission technology that can help California's air districts meet these air quality goals.

University of California, Irvine: Advanced Power & Energy Program (APEP) (Email #9)

Comment:

We are writing to address comments made by workshop participants suggesting that renewable natural gas (RNG) use in heavy-duty vehicle (HDV) applications receive a research focus. Specifically, we are responding to comments made by the California Bioenergy Association (CBA) that an assessment is needed to address the remaining barriers to RNG use in transportation. We agree with the comments that addressing barriers to producing and using RNG fuels in the

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transportation sector is an important research area, particularly for HDV. However, in regards to the suggestion that an assessment is needed, we note that APEP is directly addressing this research need via a three year project funded by the California Air Resources Board studying the best use of renewable fuels in the HDV sector. The project, entitled “The Optimal Route for a Clean Heavy Duty Sector in California”, will assess the potential implementation of renewable pathways including biomass and biogas (including RNG), power-to-gas, and vehicle-to-grid strategies to support fuel production and distribution for HDV to determine preferred uses and strategies in meeting California’s long-term energy and environmental goals. The analysis will characterize and quantify associated economics and emissions of GHG and criteria pollutants of different fuel pathways across an encompassing set of scenarios considering a range of advanced vehicle technologies in 2050. Additionally, a component of the project is to “Provide guidance on overcoming barriers to implementing zero and near-zero emission heavy duty pathways”. Therefore, APEP will specifically seek to identify the best production methods of RNG for HDV use, as well as to identify and suggest potential methods to overcome current barriers, which directly addresses the issue raised by the CBA.

However, APEP would like to encourage the CEC to pursue additional research associated with the use of RNG in the transportation sector to ensure the maximum attainment of environmental co-benefits from RNG production and utilization in California. For example, the use of RNG may be most feasible for reducing GHG within other transportation sub-sectors including off-road sources, ships, rail, and aircraft.

Improving the environmental performance of fuel production and use within those areas can attain important environmental quality benefits, including improvements to regional air quality. For example, Figure 1 below demonstrates the notable impact on ozone and PM2.5 air pollution from off-road sources in 2035, highlighting the need for deployment of zero- and near-zero emission technology development and deployment. The use of RNG to supply fuel for off-road sources can ensure the co-benefit of GHG reduction.

Additional areas of research APEP believes should be supported by CEC investment include:

- Barriers to, and best practices, for RNG production and use in other transportation sectors including off-road, rail, ships, and aircraft
- Air quality impacts of increased ammonia emissions arising from post-combustion clean-up systems utilized by NG and RNG HDV
- The environmental impacts (air quality, GHG, water) of biomass distribution for energy recovery
- Consideration of resource availability and impacts from utilization of RNG feedstocks at the national level

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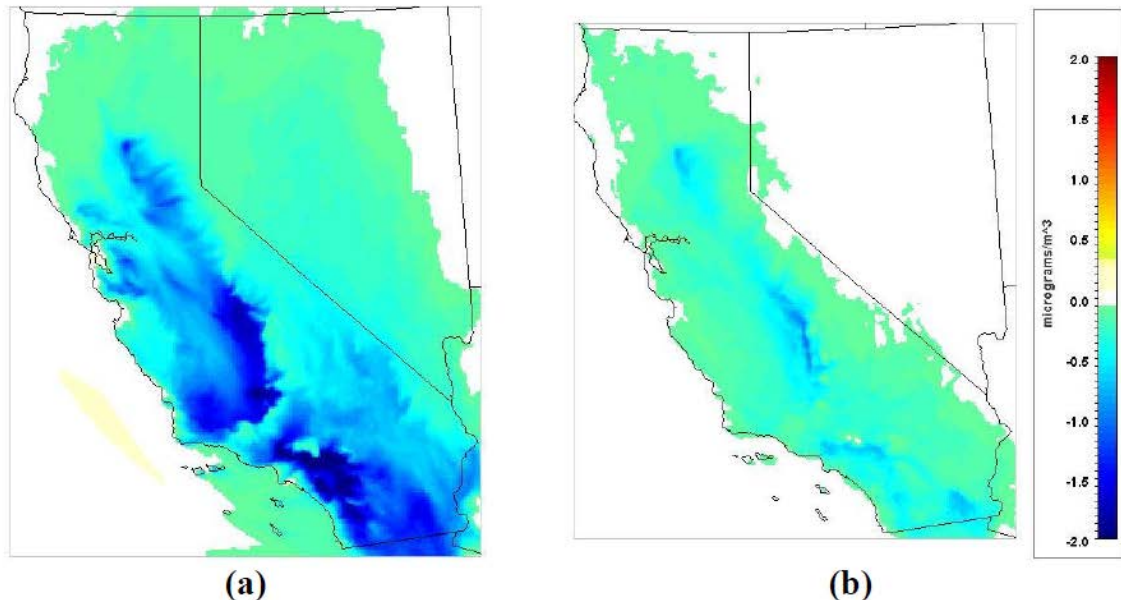


Figure 1. Predicted impacts on a) max 8-h avg. ozone and b) 24-hr avg. PM_{2.5} from off-road sources in 2035.

Energy Commission Response:

Energy Commission staff are aware of UCI's "The Optimal Route for a Clean Heavy Duty Sector in California" project and will consider its findings when pursuing research in natural gas-related transportation. Staff will consider conducting future assessments that can address the additional areas of research identified in APEP's comment.

The Energy Commission is also aware of the high potential GHG and air quality benefits of increased RNG use in large off-road applications such as rail and marine. The Energy Commission has recently published a report developed by Gladstein, Neandross, & Associates titled "The Feasibility, Issues, and Benefits Associated with Expanded Use of Natural Gas at Seaports and Other High Horsepower Applications".¹ The report focuses on marine vessels and locomotives as key high horsepower port applications that consume high volumes of fuel, have high associated environmental impacts, and offer the potential to achieve significant environmental benefits by using RNG. The proposed Natural Gas R&D program expansion could allow the Energy Commission to fund larger research projects that may be needed to address the remaining barriers to increasing RNG utilization in large off-road applications.

¹ Leonard, J. and Couch, P. The Feasibility, Issues, and Benefits Associated With Expanded Use of Natural Gas at Seaports and Other High Horsepower Applications. <http://www.energy.ca.gov/2017publications/CEC-500-2017-032/CEC-500-2017-032.pdf>